VARDHAMAN
COLLEGE OF ENGINEERING

CURRICULUM
For
Bachelor of Technology
Electronics and Communication Engineering

Under
Choice Based Credit System (CBCS)

B. Tech. - Regular Four-Year Degree Program
(For batches admitted from the Academic Year 2025 - 2026)

&

B. Tech. - Lateral Entry Scheme
(For batches admitted from the Academic Year 2026 - 2027)

August 2025

VARDHAMAN COLLEGE OF ENGINEERING
(Autonomous)
Affiliated to **JNTUH,** Approved by **AICTE,** Accredited by **NAAC** with **A++** Grade
Kacharam, Shamshabad, Hyderabad- 501 218, Telangana, India
www.vardhaman.org, info@vardhaman.org

Department Vision

To produce competent engineers with social responsibility to address the global challenges in the field of Electronics and Communication Engineering.

Department Mission

M1: Promote active learning strategies to facilitate student centric learning.

M2: Provide self learning capabilities to enhance employability and entrepreneurial skills.

M3: Inculcate human values and ethics to make learners sensitive towards societal issues.

M4: Strengthen core competencies among the learners through experiential curriculum.

Program Educational Objectives (PEOs)

PEO1: Graduates will demonstrate continuous learning and professional growth in the field of Electronics and Communication Engineering, adapting to rapidly changing technologies and staying relevant in the ever-evolving engineering landscape.

PEO2: Graduates will be able to apply emerging global technologies to create innovative solutions that address societal challenges and promote sustainability.

PEO3: Graduates will exhibit leadership skills, innovation, and ethical responsibility in solving complex engineering problems while maintaining a strong sense of professional excellence.

PEO4: Graduates will achieve career success by contributing to organizational growth and upholding high professional standards within the industry.

Knowledge and Attitude Profile (WK)

WK1: A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.

WK2: Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.

WK3: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

WK4: Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

WK5: Knowledge, including efficient resource use, environmental impacts, whole-life cost,reuse of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.

WK6: Knowledge of engineering practice (technology) in the practice areas in theengineering discipline.

WK7: Knowledge of the role of engineering insociety and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.

WK8: Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.

WK9: Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering Knowledge: Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.

PO2: Problem Analysis: Identify, formulate, review research literature and analyze complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4).

PO3: Design/ Development of Solutions: Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5).

PO4: Conduct investigations of complex problems: Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).

PO5: Modern Tool Usage: Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6).

PO6: The Engineer and The World: Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).

PO7: Ethics: Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

PO8: Individual and Collaborative Team work: Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

PO9: Communication: Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

PO10: Project Management and Finance: Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

PO11: Life-Long Learning: Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

Program Specific Outcomes (PSOs)

PSO1: Apply the knowledge of domain-specific skill set for the design and analysis of components in VLSI and Embedded Systems.

PSO2: Demonstrate the technical competency and use appropriate techniques in the realization of Advanced Communication Systems.

United Nations Sustainable Development Goals (SDGs)

SDG1: No Poverty – End poverty in all its forms everywhere.

SDG2: Zero Hunger – End hunger, achieve food security and improved nutrition and promote sustainable agriculture.

SDG3: Good Health and Well-Being – Ensure healthy lives and promote well-being for all at all ages.

SDG4: Quality Education – Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.

SDG5: Gender Equality – Achieve gender equality and empower all women and girls.

SDG6: Clean Water and Sanitation – Ensure availability and sustainable management of water and sanitation for all.

SDG7: Affordable and Clean Energy – Ensure access to affordable, reliable, sustainable and modern energy for all.

SDG8: Decent Work and Economic Growth – Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

SDG9: Industry, Innovation and Infrastructure – Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

SDG10: Reduced Inequalities – Reduce inequality within and among countries.

SDG11: Sustainable Cities and Communities – Make cities and human settlements inclusive, safe, resilient and sustainable.

SDG12: Responsible Consumption and Production – Ensure sustainable consumption and production patterns.

SDG13: Climate Action – Take urgent action to combat climate change and its impacts.

SDG14: Life Below Water – Conserve and sustainably use the oceans, seas and marine resources for sustainable development.

SDG15: Life on Land – Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

SDG16: Peace, Justice and Strong Institutions – Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels.

SDG17: Partnerships for the Goals – Strengthen the means of implementation and revitalize the global partnership for sustainable development.

I B.Tech. I Semester												
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1	A9001	Matrices and Calculus	BS	45	15	-	60	120	4	40	60	100
2	A9007	Engineering Physics	BS	45	-	-	45	90	3	40	60	100
3	A9501	Programming for Problem Solving	ES	45	-	-	45	90	3	40	60	100
4	A9202	Principles of Electrical Engineering	ES	45	-	-	45	90	3	40	60	100
5	A9401	Digital Logic Design	ES	30	-	-	30	60	2	40	60	100
Practical Courses												
6	A9008	Engineering Physics Laboratory	BS	-	-	30	-	30	1	40	60	100
7	A9502	Programming for Problem Solving Laboratory	ES	-	-	30	-	30	1	40	60	100
8	A9203	Principles of Electrical Engineering Laboratory	ES	-	-	30	-	30	1	40	60	100
9	A9302	Engineering Workshop	ES	-	-	30	-	30	1	40	60	100
Community Related Project Work												
10	A9021	Community Centered Design Thinking	PW	-	-	-	45	45	1	40	60	100
Total				210	15	120	270	615	20	400	600	1000

I B.Tech. II Semester												
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1	A9002	Ordinary Differential Equations and Vector Calculus	BS	45	15	-	60	120	4	40	60	100
2	A9009	Engineering Chemistry	BS	45	-	-	45	90	3	40	60	100
3	A9011	English for Skill Enhancement	HS	30	-	-	30	60	2	40	60	100
4	A9503	Data Structures	ES	45	-	-	45	90	3	40	60	100
5	A9403	Electronic Devices and Circuits	ES	45	-	-	45	90	3	40	60	100
Practical Courses												
6	A9010	Engineering Chemistry Laboratory	BS	-	-	30	-	30	1	40	60	100
7	A9012	English Language and Communication Skills Laboratory	HS	-	-	30	-	30	1	40	60	100
8	A9504	Data Structures Laboratory	ES	-	-	30	-	30	1	40	60	100
9	A9304	Computer Aided Engineering Graphics	ES	-	-	30	-	30	1	40	60	100
Community Related Project Work												
10	A9022	Product Design and Development	PW	-	-	-	45	45	1	40	60	100
Total				210	15	120	270	615	20	400	600	1000

II B.Tech. I Semester													
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
1	A9003	Numerical Methods and Complex Variables	BS	45	-	-	45	90	3	40	60	100
2	A9404	Probability and Random Processes	ES	45	-	-	45	90	3	40	60	100
3	A9405	Electronic Circuit Analysis	PC	45	-	-	45	90	3	40	60	100
4	A9406	Signals and Systems	PC	45	-	-	45	90	3	40	60	100
5	A9407	Linear Control Systems	PC	45	-	-	45	90	3	40	60	100
Practical Courses												
6	A9408	Electronic Devices and Circuit Analysis Laboratory	PC	-	-	30	-	30	1	40	60	100
7	A9409	System Modelling and Simulation Laboratory	PC	-	-	30	-	30	1	40	60	100
8	A9410	Applied Python Programming Laboratory	PC	-	-	30	-	30	1	40	60	100
9	A9006	Computational Mathematics Laboratory	BS	-	-	30	-	30	1	40	60	100
Skill Development Course												
10	A9411	Linux and Shell Scripting	PC	-	-	30	-	30	1	40	60	100
Community Related Project Work												
11	A9023	Technology Entrepreneurship	PW	-	-	-	45	45	1	40	60	100
Total				225	0	150	270	645	21	440	660	1100

II B.Tech. II Semester													
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
Theory Courses												
1	A9014	Business Economics and Financial Analysis	HS	45	-	-	45	90	3	40	60	100
2	A9414	Digital Signal Processing	PC	45	-	-	45	90	3	40	60	100
3	A9415	Integrated Circuits and Applications	PC	45	-	-	45	90	3	40	60	100
4	A9416	RISC Architectures and ARM Microcontrollers	PC	45	-	-	45	90	3	40	60	100
5	A9417	Electromagnetic Fields and Transmission Lines	PC	45	15	-	60	120	4	40	60	100
Practical Courses												
6	A9418	Digital Signal Processing Laboratory	PC	-	-	30	-	30	1	40	60	100
7	A9419	Integrated Circuits and Applications Laboratory	PC	-	-	30	-	30	1	40	60	100
8	A9420	RISC Architectures and ARM Microcontrollers Laboratory	PC	-	-	30	-	30	1	40	60	100
Skill Development Course												
9	A9421	FPGA-based System Design	PC	-	-	30	-	30	1	40	60	100
Community Related Project Work												
10	A9024	Community Driven Product Evaluation	PW	-	-	-	45	45	1	40	60	100
Total				225	15	120	285	645	21	400	600	1000
11		Exit Optional: Work Based Vocational Course / Internship or Apprenticeship	PW	-	-	-	90	90	2	40	60	100

III B.Tech. I Semester													
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1	A9424	Analog and Digital Communications	PC	45	-	-	45	90	3	40	60	100
2	A9425	CMOS VLSI Design	PC	45	-	-	45	90	3	40	60	100
3	A9426	Antennas and Wave Propagation	PC	45	-	-	45	90	3	40	60	100
4		Professional Elective - I	PE	45	-	-	45	90	3	40	60	100
5		Open Elective - I	OE	45	-	-	45	90	3	40	60	100
Practical Courses												
6	A9427	Analog and Digital Communications Laboratory	HS	-	-	30	-	30	1	40	60	100
7	A9428	CMOS VLSI Design Laboratory	PC	-	-	30	-	30	1	40	60	100
Skill Development Course												
8	A9429	Audio and Visual Signal Processing	PC	-	-	30	-	30	1	40	60	100
Experiential Learning Course												
9	A9041	Internship/Industrial Training	PW	-	-	-	90	90	2	40	60	100
Value Added Course												
10	A9015	Environmental Science	VA	15	-	-	15	30	1	40	60	100
Total				240	0	90	330	660	21	400	600	1000

III B.Tech. II Semester													
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1	A9430	Computer Communication Networks	PC	45	-	-	45	90	3	40	60	100
2	A9431	VLSI Functional Verification Methodologies	PC	45	-	-	45	90	3	40	60	100
3	A9432	Real Time Embedded Systems	PC	45	-	-	45	90	3	40	60	100
4		Professional Elective - II	PE	45	-	-	45	90	3	40	60	100
5		Open Elective - II	OE	45	-	-	45	90	3	40	60	100
Practical Courses												
6	A9013	English for Employability Skills Laboratory	HS	-	-	30	-	30	1	40	60	100
7	A9433	VLSI Functional Verification Methodologies Laboratory	PC	-	-	30	-	30	1	40	60	100
Skill Development Course												
8	A9434	Real Time Operating Systems	PC	-	-	30	-	30	1	40	60	100
Experiential Learning Course												
9	A9042	Mini Project	PW	-	-	-	90	90	2	40	60	100
Value Added Course												
10	A9016	Gender Sensitization, Human Values and Professional Ethics	VA	15	-	-	15	30	1	40	60	100
Total				240	0	90	330	660	21	400	600	1000

IV B.Tech. I Semester													
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1	A9437	Wireless Communications and Networks	PC	45	-	-	45	90	3	40	60	100
2	A9438	IoT Architectures and Protocols	PC	45	-	-	45	90	3	40	60	100
3		Professional Elective - III	PE	45	-	-	45	90	3	40	60	100
4		Professional Elective - IV	PE	45	-	-	45	90	3	40	60	100
5		Open Elective - III	OE	45	-	-	45	90	3	40	60	100
Practical Courses												
6	A9439	Advanced Communications and Networks Laboratory	PC	-	-	30	-	30	1	40	60	100
7	A9440	IoT Architectures and Protocols Laboratory	PC	-	-	30	-	30	1	40	60	100
Experiential Learning Course												
8	A9043	Major Project – Phase I	PW	-	-	-	90	90	2	100	-	100
Value Added Course												
9	A9017	Indian Knowledge System	VA	15	-	-	15	30	1	40	60	100
Total				240	0	60	330	630	20	420	480	900

IV B.Tech. II Semester												
#	Course Code	Title of the Course	Category	Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
				CI		LI	TW + SL	H	C	CIE	SEE	Total
				L	T	P	SL					
Theory Courses												
1		Professional Elective – V	PE	45	-	-	45	90	3	40	60	100
2		Professional Elective – VI	PE	45	-	-	45	90	3	40	60	100
Experiential Learning Course												
3	A9044	Major Project – Phase II	PW	-	-	-	630	630	14	40	60	100
Total				90	0	0	720	810	20	120	180	300

Common Abbreviations Used in the Curriculum

BS – Basic Sciences
HS – Humanities & Social Sciences
ES – Engineering Sciences
PC – Professional Core
PE – Professional Elective
OE – Open Elective
PW – Project Work
VA – Value Added Course
CI – Classroom Instruction
LI – Laboratory Instruction
L – Lecture Hours
T – Tutorial Hours
P – Practical Hours
TW – Team Work
SL – Self Learning
H – Hours
C – Credits
CIE – Continuous Internal Evaluation
SEE – Semester End Examination
SDG – Sustainable Development Goals

List of Professional Electives

Domain: VLSI System Design			
Year & Semester	**Professional Elective #**	**Course Code**	**Title of the Course**
III B.Tech. I Semester	Professional Elective – I	A9451	FPGA Based Hardware Accelerators
III B.Tech. II Semester	Professional Elective – II	A9455	VLSI Physical Design Automation
IV B.Tech. I Semester	Professional Elective – III	A9459	CMOS Analog IC Design
IV B.Tech. I Semester	Professional Elective – IV	A9463	Low Power and High Speed VLSI Design
IV B.Tech. II Semester	Professional Elective – V	A9467	Machine Learning for Hardware Design
IV B.Tech. II Semester	Professional Elective – VI	A9471	Design for Testability

Domain: Embedded Systems			
Year & Semester	**Professional Elective #**	**Course Code**	**Title of the Course**
III B.Tech. I Semester	Professional Elective – I	A9452	Embedded System Design
III B.Tech. II Semester	Professional Elective – II	A9456	Advanced Embedded Processors and Programming
IV B.Tech. I Semester	Professional Elective – III	A9460	IoT Edge Computing
IV B.Tech. I Semester	Professional Elective – IV	A9464	Sensors and Actuators
IV B.Tech. II Semester	Professional Elective – V	A9468	Embedded Wireless Sensor Networks
IV B.Tech. II Semester	Professional Elective – VI	A9472	Electronics Measurements and Instrumentation

Domain: Signal Processing			
Year & Semester	**Professional Elective #**	**Course Code**	**Title of the Course**
III B.Tech. I Semester	Professional Elective – I	A9453	Digital Image Processing
III B.Tech. II Semester	Professional Elective – II	A9457	Machine Learning for Signal Processing
IV B.Tech. I Semester	Professional Elective – III	A9461	Machine Learning for Visual Analysis
IV B.Tech. I Semester	Professional Elective – IV	A9465	Artificial Neural Networks
IV B.Tech. II Semester	Professional Elective – V	A9469	Speech Processing
IV B.Tech. II Semester	Professional Elective – VI	A9473	Biomedical Signal Processing

Domain: Communications			
Year & Semester	**Professional Elective #**	**Course Code**	**Title of the Course**
III B.Tech. I Semester	Professional Elective – I	A9454	Information Theory and Coding
III B.Tech. II Semester	Professional Elective – II	A9458	Microwave and Optical Communications
IV B.Tech. I Semester	Professional Elective – III	A9462	Software Defined Radio
IV B.Tech. I Semester	Professional Elective – IV	A9466	Satellite and Radar Communications
IV B.Tech. II Semester	Professional Elective – V	A9470	5G Wireless Communications
IV B.Tech. II Semester	Professional Elective – VI	A9474	Quantum Communications

List of Open Electives

Industry Skills		
#	Course Code	Title of the Course
1	A9505	Computer Organization
2	A9507	Operating Systems
3	A9509	Database Management Systems
4	A9515	Software Engineering
5	A9604	Web Application Engineering
6	A9612	Information Security
7	A9681	Cyber Security
8	A9682	Java Programming
9	A9683	Prompt Engineering
10	A9701	Artificial Intelligence
11	A9702	Machine Learning
12	A9705	Deep Learning
13	A9707	Natural Language Processing
14	A9710	Generative AI
15	A9803	Data Mining
16	A9851	Data Science for Engineers
Emerging Technologies		
#	Course Code	Title of the Course
17	A9381	Fundamentals of Robotics
18	A9382	Introduction to 3D Printing
19	A9383	Hybrid Vehicles
20	A9481	Internet of Things (IoT)
21	A9482	Consumer Electronics
22	A9483	VLSI Design Fundamentals
23	A9484	PCB Design and Fabrication
24	A9656	Blockchain Technology
Sustainability		
#	Course Code	Title of the Course
25	A9166	Smart Cities
26	A9181	Disaster Management
27	A9182	Road Safety Engineering
28	A9183	Building Science and Technology
29	A9281	Renewable Energy Systems
30	A9282	Smart Grid Technologies
31	A9283	Electrical Safety and Sustainable Engineering Practices
32	A9284	Smart Power Systems for Data Centers
33	A9285	E-Waste Management

List of Open Electives (Continued...)

Entrepreneurship		
#	Course Code	Title of the Course
34	A9081	Entrepreneurship Development
35	A9082	Research Methodology and IPR
36	A9083	Principles of Management
37	A9084	Organizational Behavior
38	A9355	Operations Research
39	A9684	E-Commerce
Life Skills and Holistic Development		
#	Course Code	Title of the Course
40	A9085	Emotional Intelligence and Leadership
41	A9086	Yoga and Wellness
42	A9087	National Cadet Corps (NCC)

I B.Tech. I Semester

A9001 – Matrices and Calculus

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	15	0	60	120	4	40	60	100

Course Description

Course Overview

This course provides mathematical knowledge required to analyze problems encountered in engineering. In this course, the students are acquainted with the solution of system of linear equations, eigen values and eigen vectors, functions of several variables, multiple integrals. The course is designed to build conceptual clarity and problem-solving skills, with emphasis on both theoretical understanding and practical applications.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

Course Outcomes

After the completion of the course, the student will be able to:

A9001.1. Solve system of equations using rank of a matrix.

A9001.2. Construct the canonical form of a quadratic form using orthogonal transformations.

A9001.3. Express a function in series by mean value theorems and evaluate improper integrals using Beta and Gamma functions.

A9001.4. Examine the extremum of a function of several variables.

A9001.5. Apply multiple integrals to find the areas and volumes.

Course Syllabus

Unit-I:

Matrices: Rank of a matrix by Echelon form and Normal form, Inverse of Non- singular matrices by Gauss-Jordan method, System of linear equations: Solving system of Homogeneous and Non-Homogeneous equations by Gauss elimination method, Gauss Jacobi and Gauss Seidel Iteration Method.

Unit-II:

Eigen Values and Eigen Vectors: Linear Transformation and Orthogonal transformation: Eigenvalues, Eigenvectors and their properties, Diagonalization of a matrix, Cayley- Hamilton Theorem (without proof), finding inverse and power of a matrix by Cayley- Hamilton Theorem. Quadratic forms and Nature of the Quadratic Forms, Reduction of Quadratic form to canonical forms by Orthogonal Transformation.

Unit-III:

Single Variable Calculus: Limit and Continuous of functions and its properties. Mean value theorems: Rolle's theorem, Lagrange's Mean value theorem with their Geometrical Interpretation and applications, Cauchy's Mean value Theorem, Taylor's Series (All the theorems without proof), Definition of Improper Integral, Beta and Gamma functions and their applications.

Unit-IV:

Multivariable Calculus (Partial Differentiation and applications): Definitions of Limit and Continuity, Partial Differentiation: Euler's Theorem, Total derivative, Jacobian, Functional dependence & independence. Applications: Maxima and minima of functions of two variables and three variables using method of Lagrange multipliers.

Unit-V:

Multivariable Calculus (Integration): Evaluation of Double Integrals (Cartesian and polar coordinates), change of order of integration (only Cartesian form), Change of variables for double integrals (Cartesian to polar), Evaluation of Triple Integrals. Applications: Areas by double integrals and volumes by triple integrals.

Books and Materials

Text Books:

1. Grewal, B. S. *Higher Engineering Mathematics*, 43rd ed., Khanna Publications, 2015.
2. Jain, R. K., Iyengar, S. R. K. *Advanced Engineering Mathematics*, 5th ed., Narosa Publishing House, 2016.

Reference Books:

1. Seymour Lipschutz and Marc Lars Lipson *Schaum's Outline of Linear Algebra* , 6th ed., McGraw-Hill Education, 2018.
2. Greenberg Michael D.*Advanced Engineering Mathematics*, 2nd ed., Upper Saddle River, N.J. Prentice Hall, 1998.
3. Kreyszig, E. *Advanced Engineering Mathematics*, 9th ed., John Wiley & Sons, 2006.
4. Ramana, B. V. *Higher Engineering Mathematics*, 32nd reprint, McGraw Hill Education (India), 2018.

A9007 – Engineering Physics

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

The Engineering Physics course introduces the fundamental principles of quantum mechanics, semiconductor physics, quantum computing, magnetic and dielectric materials, as well as lasers and fibre optics. Students will explore theoretical foundations, material properties, and device concepts alongside their practical applications in modern technologies such as electronics, communication, sensing, and computing systems. This course bridges core physics concepts with real-world innovations, preparing learners for advanced studies and research in emerging technologies.

Course Pre/Co-requisites

This course has no specific prerequisites and co requisites.

Relevant Sustainable Development Goals (SDGs)

SDG 7: Affordable and Clean Energy

SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9007.1. Apply quantum mechanical principles to understand the particle behavior and formation of energy bands in solids.

A9007.2. Analyze semiconductor properties and explain the operation of P–N junction diode and their applications.

A9007.3. Apply quantum gates to design quantum circuits and implement fundamental quantum algorithms.

A9007.4. Analyze magnetic and dielectric properties relevant to modern technological applications.

A9007.5. Apply laser and fibre optic principles to communication and sensing technologies.

Course Syllabus

Unit-I:

Quantum Mechanics: Introduction, de-Broglie hypothesis, Heisenberg uncertainty principle, physical significance of wave function, postulates of quantum mechanics: operators in quantum mechanics, eigen values and eigen functions, Schrödinger's time independent wave equation, particle in a 1D box, Bloch's theorem (qualitative), Kronig-Penney model (qualitative): E-k diagram, effective mass of electron, formation of energy bands, origin of band gap, classification of solids, concept of discrete energy levels.

Unit-II:

Semiconductor Physics: Intrinsic semiconductors, density of states, Fermi-Dirac distribution function, carrier concentration in intrinsic semiconductors, direct and indirect band gap semiconductors, extrinsic semiconductors, characteristics of P-N junction diode, applications: Light Emitting Diode (LED), solar cell, Hall effect.

Unit-III:

Quantum Computing: Introduction, linear algebra for quantum computation, Dirac's Bra and Ket notation and their properties, Hilbert space, Bloch's sphere, concept of quantum computer, classical bits, Qubits, multiple Qubit system, quantum computing system for information processing, evolution of quantum systems, quantum measurements, entanglement, quantum gates (Hadamard, CNOT, Toffoli), challenges and advantages of quantum computing over classical computation, Introduction to quantum algorithms: Deutsch-Jozsa, Shor, Grover (Qualitative).

Unit-IV:

Magnetic and Dielectric Properties: Introduction to magnetic materials, origin of magnetic moment, classification of magnetic materials (dia, para, ferro), Weiss domain theory of ferromagnetism, hysteresis, soft and hard magnetic materials, applications: magnets for EV, Giant Magneto Resistance (GMR) device. Introduction to dielectric materials, types of polarization (qualitative): electronic, ionic & orientational; ferroelectric, piezoelectric, pyroelectric materials and their applications: Ferroelectric Random-Access Memory (Fe-RAM), load cell and fire sensor.

Unit-V:

Lasers and Fibre Optics: Introduction to laser, characteristics of laser, Einstein coefficients and their relations, metastable state, population inversion, pumping, lasing action, Ruby laser, He-Ne laser, semiconductor diode laser, applications: Bar code scanner, LIDAR for autonomous vehicle. Introduction to fibre optics, total internal reflection, construction of optical fibre, acceptance angle, numerical aperture, classification of optical fibres, losses in optical fibres, applications: optical fibre for communication system, sensor for structural health monitoring.

Books and Materials

Text Books:

1. T. Vijaya Krishna, T. Madhu Mohan, B.K. Pandey, Manoj K. Harbola, and S. Chaturvedi. *Physics for Engineers.* 2nd ed., Cengage, 2024.
2. M. N. Avadhanulu, P. G. Kshirsagar, and T. V. S. Arun Murthy. *A Textbook of Engineering Physics.* 13th ed., S. Chand & Company Pvt. Ltd., 2023.
3. Thomas G. Wong. *Introduction to Classical and Quantum Computing.* Rooted Grove.

Reference Books:

1. Jozef Gruska. *Quantum Computing.* McGraw Hill Education, 1999.
2. Michael A. Nielsen and Isaac L. Chuang. *Quantum Computation and Quantum Information.* Cambridge University Press, 2010.
3. John M. Senior. *Optical Fiber Communications: Principles and Practice.* Pearson Education Limited, 2009.

A9501 – Programming for Problem Solving

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces the principles of problem-solving and programming through C language. It begins with the basics of algorithms, flowcharts, and structured program design, enabling students to develop logical thinking skills. Core programming concepts such as variables, operators, control statements, arrays, and strings are covered to build a strong foundation. The course further explores modular programming using functions and recursion, along with structures and unions for handling complex data. Advanced concepts like pointers and dynamic memory management are introduced to enhance program efficiency. File handling techniques are discussed for effective data storage and retrieval. Fundamental searching and sorting algorithms are included to improve problem-solving efficiency and performance analysis. By the end of the course, students will be able to design, implement, and evaluate C programs that solve real-world computational problems systematically and efficiently.

Course Pre/Co-requisites

This Course has no specific Pre/Co requisites

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9501.1. Use basic programming constructs and control statements to design solutions for computational problems.

A9501.2. Develop programs using arrays and strings to store and manipulate sequential data.

A9501.3. Implement modular programming using functions, structures, and unions to manage complex problems and data.

A9501.4. Make use of pointers and file handling to effectively manage and process data.

A9501.5. Choose appropriate searching and sorting technique to organize and retrieve data efficiently.

Course Syllabus

Unit-I:

Problem Solving Techniques: Algorithms- Algorithmic approach, characteristics of algorithm and Examples, Flowcharts- Definition, Symbols and examples, Problem solving strategies: Top-down approach and Bottom-up approach.

Introduction to C: Structure of a C Program, Identifiers, Variables, Constants and Data Types. Operators and Expressions. Precedence of operators and Evaluation of Expressions, Type conversions, Formatted input and output. Control Statements: Conditional Statements- if, if else, nested if, else if ladder and switch statements. Iterative or Loop statements- while, do while and for statements. Jump statements- break, continue and goto statements.

Unit-II:

Arrays and Strings: Arrays: Introduction, One Dimensional Arrays - Declaration and initialization, Reading and Writing. Two Dimensional Arrays - Declaration and initialization, Reading and Writing. Manipulating elements of Arrays. Strings: Introduction, Declaration, and initialization, Reading and writing, string handling functions, handling two dimensional strings.

Unit-III:

Functions, Structures and Unions: Functions- Introduction, Function definition and Function call, Categories of functions, Recursion, Limitations of recursive functions, storage classes, Passing Arrays to functions, Common Pre-processor Directives. Structures- Definition, Declaration, and Initialization, accessing structure members, Array of Structures, Arrays within structures, Structures and functions, size of structures, Unions- Definition, Declaration, and Initialization, accessing Union member.

Unit-IV:

Pointers and Files: Pointers-Declaration, Initialization, Pointer to Pointer, Pointer Arithmetic, Parameter Passing Techniques, Pointer to Arrays, Pointers to Structures. Files- Introduction, defining, opening, and closing a File, Input / Output operations on Files, Random Access in files, Command line arguments.

Unit-V:

Searching and Sorting: Time and Space Complexity, Searching- Linear Search and Binary Search, Sorting- Bubble Sort, Selection Sort, Insertion Sort and Quick Sort.

Books and Materials

Text Books:

1. Thareja, Reema. *Programming in C.* AICTE ed., 2nd rev. ed., Oxford University Press, 2018.
2. Forouzan, Behrouz A., and Richard F. Gilberg. *Computer Science: A Structured Programming Approach Using C*, 3rd ed., reprint, Cengage Learning (formerly Course Technology), 2007.

Reference Books:

1. Kanetkar, Yashavant P. *Let Us C: Authentic Guide to C Programming Language.*, 20th ed., reprint, BPB Publications, 2024.
2. Gottfried, Byron S. *Programming with C.*, 4th ed., reprint, McGraw-Hill Education (India), 2018.
3. Padmanabham, P. *C & Data Structures.*, 3rd ed., B.S. Publications, 2016.
4. Hanly, Jeri R., and Elliot B. Koffman. *Problem Solving and Program Design in C.*, 8th ed., reprint, Pearson, 2015.
5. Balagurusamy, E. *Programming in ANSI C.*, 9th ed., reprint, McGraw-Hill Education India, 2024.

A9202 – Principles of Electrical Engineering

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides a foundational understanding of electrical engineering concepts essential for students of electronics and communication engineering. It introduces the core principles of DC and AC circuit analysis, network theorems, transient behavior, and basic electrical machines. Emphasis is placed on understanding electrical circuit behavior, solving numerical problems, and building analytical skills relevant to electronics. The concepts learned will support further studies in analog/digital circuits and communication systems.

Course Pre/Co-requisites

The course has no specific pre-requisite and co-requisite

Relevant Sustainable Development Goals (SDGs)

SDG 7: Affordable and Clean Energy
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9202.1. Apply Ohm's Law, Kirchhoff's Laws, nodal and mesh analysis methods to simplify complex electrical circuits.

A9202.2. Apply network theorems to simplify complex electrical circuits and evaluate two-port network parameters.

A9202.3. Analyze transient response of series RL, RC and RLC circuits for DC excitation.

A9202.4. Analyze single-phase AC circuits and resonance conditions in RLC circuits under sinusoidal excitation.

A9202.5. Apply the principles of operation to analyze the construction, characteristics, and applications of DC motors and stepper motors used in electromechanical systems.

Course Syllabus

Unit-I:

DC Circuits: Electrical circuit elements (R, L and C), Ohm's Law, KVL and KCL, Types of sources, Source transformation, Network reduction techniques (Series, Parallel and Star-Delta), Mesh and Nodal analysis with DC excitation.

Unit-II:

Network Theorems: Superposition theorem, Thevenin's theorem, Norton's theorem and Maximum power transfer theorem with DC Excitation - Numerical problems.

Two-Port Parameters: Introduction to two port networks, Types of two-port networks, analysis of Impedance(Z) parameters, Admittance(Y) parameters, ABCD parameters and Hybrid(h) Parameters with DC Excitation - Numerical problems.

Unit-III:

Transient Analysis: Behavior of R,L and C elements in initial conditions and steady state conditions. Transient response of R-L, R-C, R-L-C circuits (Series and Parallel) for D.C Excitation, Transient solutions of networks using differential equations only.

Unit-IV:

AC Circuits: Representation of sinusoidal waveforms, Analysis of single-phase AC circuits consisting of R, L, C, RL, RC, RLC combinations (series circuits only) - Numerical problems.

Resonance: Resonance for series and parallel circuits, tank circuit, concept of band width and Q-factor.

Unit-V:

D.C Motors: Construction of DC machine, Principle of operation of DC motor, Concept of Back E.M.F., Torque equation, Torque-Speed characteristics of DC Shunt motor, Applications of DC motor. (Conceptual description only).

Stepper Motors: Working Principle of Stepper Motor, Constructional features of Permanent Magnet (PM), Variable Reluctance (VR), Hybrid Stepper Motors. Step Angle, Resolution and Applications of Stepper Motors. (Conceptual description only).

Books and Materials

Text Books:

1. Alexander, Charles K., and Matthew N. O. Sadiku. *Fundamentals of Electric Circuits.* 7th ed., Tata McGraw Hill, 2015.
2. Sudhakar, D. A., and Shyammohan S. Palli. *Network Analysis.* 4th ed., Tata McGraw Hill, 2018.
3. Theraja, B. L., and A. K. Theraja. *A Textbook of Electrical Technology.* 23rd ed., S. Chand Publishers, 2002.

Reference Books:

1. Hayt, William H., Jack E. Kemmerly, and Steven M. Durbin. *Engineering Circuit Analysis.* 9th ed., McGraw-Hill Higher Education, 2007.
2. Bimbra, P. S. *Electrical Machinery.* 7th ed., Khanna Publishers, 2000.

A9401 – Digital Logic Design

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	30	60	2	40	60	100

Course Description

Course Overview

This course provides a comprehensive introduction to digital logic design, focusing on the principles of Boolean algebra, logic gates, and logic function implementation. Students will learn techniques for minimizing logic expressions using Karnaugh maps and designing combinational circuits such as adders, comparators, multiplexers, and decoders. The course also covers sequential logic components including latches, flip-flops, counters, and shift registers. Further, students will explore the design of synchronous sequential circuits using state machines (Mealy and Moore models) and examine memory elements and programmable logic devices such as ROM, RAM, PLA, and PAL. Emphasis is placed on analysis, simplification, and implementation of digital systems at the gate level.

Course Pre/Co-requisites

This course has no specific prerequisites and co-requisites

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9401.1. Apply Boolean laws and theorems to implement digital logic functions using basic and universal gates.

A9401.2. Simplify logic expressions using Karnaugh maps to obtain optimized SOP and POS implementations.

A9401.3. Design combinational circuits using logic gates to meet functional requirements.

A9401.4. Analyze the behavior of latches and flip-flops for sequential logic design.

A9401.5. Design synchronous sequential circuits, including memory and programmable logic devices, for digital system design.

Course Syllabus

Unit-I:

Boolean Algebra and Logic Gates: Introduction, basic definitions, axiomatic definition of Boolean algebra, basic theorems and properties of Boolean algebra, Boolean functions, canonical and standard forms (SOP, POS), Digital logic gates, NAND-NOR realization.

Unit-II:

Gate-Level Minimization Techniques: Introduction, The Map method (Karnaugh Map) - 2, 3, and 4 variable K-map, Sum-of-Products and Product-of-Sums Simplification, Don't care conditions.

Unit-III:

Combinational Logic: Introduction, combinational circuits, analysis of combinational circuits, design procedure, binary adder-subtractor, magnitude comparator, decoders, encoders, multiplexers.

Unit-IV:

Sequential Logic: Introduction, sequential circuits, storage elements – latches and flip-flops, flip-flop conversions (JK to SR, JK to D, D to T), Design of counters - Synchronous and asynchronous counters, Shift registers – register with parallel load and serial-in serial-out shift register, universal shift register.

Unit-V:

Synchronous Sequential Logic: Finite State Machines (FSM) - Mealy and Moore models, state diagrams and state tables, state assignment and state reduction. **Memory and Programmable Logic Devices:** Random Access Memory (RAM), Read-Only Memory (ROM), Programmable ROM (PROM), Programmable Logic Array (PLA), Programmable Array Logic (PAL).

Books and Materials

Text Books:

1. Mano, M. Morris, and Michael D. Ciletti. *Digital Design with an Introduction to the Verilog HDL.* 6th ed., Pearson Education/PHI, 2017.

Reference Books:

1. Tocci, Ronald J., Neal S. Widmer, and Gregory L. Moss. *Digital Systems: Principles and Applications.* 10th ed., Pearson Education International, 2009.
2. Roth, Charles H., Jr., and Larry L. Kinney. *Fundamentals of Logic Design.* 6th ed., Cengage Learning, 2009.

A9008 – Engineering Physics Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

The Engineering Physics laboratory course provides hands-on experience with fundamental concepts in semiconductors, magnetism, optics, and wave phenomena. Students will conduct practical experiments including the I-V characteristics of LEDs and solar cells, Hall effect measurements, and determination of energy band gaps. The course also covers the analysis of magnetic and dielectric properties, measurement of laser wavelength, characterization of optical fibre parameters, and AC frequency determination using a sonometer. These experiments are designed to enhance conceptual understanding and develop experimental skills relevant to modern physics and engineering applications.

Course Pre/Co-requisites

This course has no specific pre-requisites and co-requisites.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 7: Affordable and Clean Energy
SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9008.1. Determine key parameters of LEDs and solar cells from their I–V characteristics.

A9008.2. Apply the Hall Effect to determine the type of semiconductor and estimate the density of majority charge carriers.

A9008.3. Evaluate material properties including energy band gap, magnetic moment, dielectric constant, and magnetic hysteresis behavior.

A9008.4. Apply the principles of lasers and optical fibres to determine laser wavelength and Numerical Aperture.

A9008.5. Apply principles of mechanical waves to determine AC supply frequency.

Course Syllabus

List of Experiments:

1. Determination of threshold voltage of LED from its I-V characteristics.
2. Study the I-V characteristics of Solar cell and find the fill factor.
3. Verification of the type of semiconductor material by estimating the density of majority carriers using the Hall Effect.
4. Determination of the energy band gap of a given semiconductor.
5. Determine the Magnetic moment of a given magnet and Horizontal component of earth's magnetic field.
6. Study of B-H curve of a ferromagnetic material.
7. Determination of dielectric constant of a given material.
8. Determination of the wavelength of a laser source using a plane transmission grating.

9. Evaluation of the numerical aperture (NA) and acceptance angle of a given optical fibre.
10. Determination of the frequency of an AC supply using a sonometer.

Laboratory Equipment/Software/Tools Required:

1. Light Emitting Diode Kit
2. Solar Cell Kit
3. Hall Effect Setup
4. Energy Gap of a Semiconductor Kit
5. Magnetic Moment Setup
6. B-H Curve Kit
7. Dielectric Constant Setup
8. Semiconductor Diode Laser
9. Plane Diffraction Grating
10. Optical Fibre Trainer Kit
11. Sonometer Setup
12. Meters – Ammeter, Voltmeter, Digital Multimeter, Deflecting Magnetometer, Thermometers

Books and Materials

Text Books:

1. Jain, Sushil Kumar, and Manjeet Singh *Applied Physics Experiments*, JBC Press, 2013.

Reference Books:

1. Mal, S. B., and Er. Ashish Jesuja *Practical Physics for Engineering Students of B.Tech*, JBC Press, 2020.

A9502 – Programming for Problem Solving Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course aims to build practical programming skills using the C language. Students learn to approach problems logically and implement solutions efficiently. Emphasis is given to writing clear and structured programs using control statements and modular design. They gain hands on experience with data handling, including arrays, strings, and user-defined data types. Pointers are introduced to manage memory and work with complex data efficiently. File operations are covered to handle data storage and retrieval. Students practice implementing algorithms for sorting, searching, and numerical computations. The course develops debugging and problem-solving abilities through practical exercises. Focus is placed on optimizing code for better performance and readability. By the end, learners can design and implement robust C programs for a variety of computational problems.

Course Pre/Co-requisites

This course has no specific pre-requisites and co-requisites.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9502.1. Make use of fundamental programming constructs to develop solutions for computational problems.

A9502.2. Perform various operations on arrays and strings to effectively organize, process, and manipulate sequential data in programs.

A9502.3. Develop programs with functions and structures to design modular programs that efficiently handle and process data.

A9502.4. Apply pointers and file handling techniques to implement programs for storing and managing data effectively.

A9502.5. Implement searching and sorting algorithms to efficiently organize and access data.

Course Syllabus

List of Experiments:

1. Variables and Expressions
   a. Write a C program for Swapping of two numbers using a third variable.
   b. Write a C program for the simple and compound interest.
   c. Write a C program to evaluate the expressions (Finding $y = m \cdot x + c$, displacement).
2. Conditional Statements–I
   a. Write a C program for finding the max and min from the three numbers.
   b. Write a C program to check the given year is leap year or not.

c. Write a C program to find the roots of a quadratic equation.

3. Conditional Statements–II
   a. Write a C program to check the given number is power of 2 or not using bitwise operators.
   b. Write a C program to read 3 subject marks. Calculate and display the grade of a student based on the percentages.
   c. Write a C program to perform Arithmetic Operations using switch statement.
4. Iterative Statements–I
   a. Write a C program to find sum of n natural numbers $(1+2+3+\cdots+n)$.
   b. Write a C program to find factorial of a given number.
   c. Write a C program to print Fibonacci numbers.
   d. Write a C program to find reverse of the given number.
   e. Write a C program to check if the binary representation of a positive number is palindrome or not. (Examples: 101, 11, 11011, 1001001 are palindromes. 100, 110, 1011 are not).
5. Iterative Statements–II
   a. Write a C program to read a password until it is correct. For wrong password print "Incorrect password" and for correct password print "Correct password" and quit the program. (The correct password is 1234).
   b. Write a C program to check the given number is prime or not.
   c. Write a C program to find the GCD of given two numbers.
   d. Write a C program to print the output in various triangle patterns using nested `for` loops.
   e. Write a C program to find the sum of the series Geometric Progression.
6. Arrays
   a. Write a C program to find the largest and smallest number among a list of integers.
   b. Write a C program to read an array of n elements and find the mean, variance, and standard deviation.
   c. Write a C program to find addition of two matrices.
   d. Write a C program to find multiplication of two matrices.
7. Strings
   a. Write a C program to demonstrate the string handling functions.
   b. Write a C program to check whether a given string is palindrome or not.
   c. Write a C program to concatenate three strings.
   d. Write a C program to count the lines, words and characters in a given text.
   e. Write a C program that displays the position of a character ch in the string S or -1 if S doesn't contain ch.
8. Functions
   a. Write a C program to find the factorial of a given number using non-recursive and recursive function.
   b. Write a C program to find the nth term of a Fibonacci series using recursive function.
   c. Write a C program to compute x^y.
9. Structures
   a. Write a C program to create a Student structure containing name, rollNo and grade as structure members. Display the name, rollNo and grade of a student.

b. Write a C program to create a Student structure containing name, rollNo and grade as structure members. Display the name, rollNo and grade of n students by using array of structures concept.

10. Structures and functions
    a. Write a C program to add two complex numbers by passing structure to a function.
    b. Write a C program to add two distances (in inch-feet system) using structures.
11. Pointers
    a. Write a C program to swap two integers using the following methods:
        i. Call by Value
        ii. Call by Reference
    b. Write a C program to demonstrate pointer arithmetic.
    c. Write a program to display values in reverse order from an array using a pointer.
    d. Write a program through a pointer variable to find sum of n elements from an array.
    e. Write a C program to check the given string is palindrome or not using pointer.
    f. Write a C program to print n city names using pointers and strings.
12. Files
    a. Write a C program to merge two files into a third file.
    b. Write a C program to reverse the contents of a file.
    c. Write a C program to use random access functions in files.
    d. Write a C program to count the number of times a character occurs in a text file (file name and character are supplied as command line arguments).
13. Searching
    a. Write a C program that uses a non-recursive function to search for a key value in a list of integers using linear search.
    b. Write a C program that uses a non-recursive function to search for a key value in a sorted list of integers using binary search.
14. Sorting
    a. Write a C program that implements the Bubble sort method to sort a given list of integers in ascending order.
    b. Write a C program that sorts the given array of integers using selection sort in descending order.
    c. Write a C program that sorts the given array of integers using quick sort in ascending order.
    d. Write a C program that sorts the given array of integers using insertion sort in ascending order.
15. Miscellaneous
    1. Write a program that shows the binary equivalent of a given positive number between 0 to 255.
    2. Write a C program to calculate the following, where x is a fractional value:

$$1 - \frac{x}{2} + \frac{x^2}{4} - \frac{x^3}{6}$$

    3. Write a C program to read in two numbers, `x` and `n`, and then compute the sum of this geometric progression:

$$1 + x + x^2 + x^3 + \cdots + x^n$$

    For example: if $n = 3$ and $x = 5$, the program computes $1 + 5 + 25 + 125$.

4. Write a C program to convert a Roman numeral ranging from I to L to its decimal equivalent.
5. Write a C program that converts a number ranging from 1 to 50 to its Roman equivalent.
6. Write a C program that uses functions to perform the following operations:
   i. To insert a sub-string into a given main string from a given position.
   ii. To delete n characters from a given position in a given string.
7. Write a C program to merge two files into a third file (i.e., the contents of the first file followed by those of the second are put in the third file).
8. Write a program for display values reverse order from an array using a pointer.
9. Write a program through a pointer variable to sum of n elements from an array.
10. Write a C program that sorts the given array of integers using insertion sort in ascending order

Laboratory Equipment/Software/Tools Required:

1. Computer Systems (PCs) installed with Ubuntu OS (Open source/ Freeware)
2. GCC Compiler (Open source/ Freeware)

Books and Materials

Text Books:

1. Thareja, Reema. *Programming in C.* AICTE ed., 2nd rev. ed., Oxford University Press, 2018.
2. Forouzan, Behrouz A., and Richard F. Gilberg. *Computer Science: A Structured Programming Approach Using C.*, 3rd ed., reprint, Cengage Learning (formerly Course Technology), 2007.

Reference Books:

1. Kanetkar, Yashavant P. *Let Us C: Authentic Guide to C Programming Language*, 20th ed., reprint, BPB Publications, 2024.
2. Gottfried, Byron S. *Programming with C*, 4th ed., reprint, McGraw-Hill Education (India), 2018.
3. Padmanabham, P. *C & Data Structures*, 3rd ed., B.S. Publications, 2016.
4. Hanly, Jeri R., and Elliot B. Koffman. *Problem Solving and Program Design in C*, 8th ed., reprint, Pearson, 2015.
5. Balagurusamy, E. *Programming in ANSI C*, 9th ed., reprint, McGraw-Hill Education India, 2024.

A9203 – Principles of Electrical Engineering Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This laboratory course introduces fundamental concepts of electrical engineering through hands-on experiments. It focuses on the practical verification of circuit laws and theorems, analysis of electrical networks, resonance, transient behavior, and basic electrical machines. Students gain experience in measuring electrical parameters, evaluating circuit performance, and understanding the operational characteristics of transformers and DC motors. The course enhances analytical thinking and bridges theoretical knowledge with practical skills essential for electronics and communication engineering applications.

Course Pre/Co-requisites

The course has no specific pre-requisite and co-requisite

Relevant Sustainable Development Goals (SDGs)

SDG 7: Affordable and Clean Energy
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9203.1. Apply Kirchhoff's Laws and fundamental network theorems to analyze DC circuits.

A9203.2. Determine two-port network parameters (Z, Y, ABCD, h) and apply them to characterize linear electrical networks.

A9203.3. Calculate and verify impedance, voltage, and current in RL, RC, and RLC series circuits and determine resonant frequency and bandwidth experimentally.

A9203.4. Analyze transient responses of series RL and RC circuits with DC excitation to interpret the time-domain voltage and current behaviors.

A9203.5. Analyze the operation and performance characteristics of DC shunt and stepper motors.

Course Syllabus

List of Experiments:

1. Verification of KVL and KCL.
2. Verification of Super position theorem.
3. Verification of Thevenin's theorem.
4. Verification of Norton's theorem.
5. Verification of Maximum power transfer theorem.
6. Determination of Z and Y parameters.
7. Determination of ABCD and h parameters.
8. Calculations and Verification of Impedance, Voltage and Current of series RL and series RC circuits.
9. Determination of Resonant frequency and band width of series RLC circuit.

10. Transient analysis of series RL and RC circuit with DC Excitation.
11. Torque-Speed Characteristics of a DC Shunt Motor.
12. Half-Step and Full-Step Operation of Stepper Motor.

Laboratory Equipment/Software/Tools Required:

1. Bread Boards, Resistors of different values, Regulated Power Supply
2. Verification of KVL and KCL Kit
3. Calculation and Verification of Impedance, Voltage and Current of RL, RC and RLC series circuits Kit
4. Function generator
5. Transient analysis of series RL/RC circuits Kit
6. Digital Oscilloscope
7. DC Machine, Stepper Motor
8. Voltmeter, Ammeter, Tachometer and Rheostats.

Books and Materials

Text Books:

1. Alexander, Charles K., and Matthew N. O. Sadiku. *Fundamentals of Electric Circuits.* 7th ed., Tata McGraw Hill, 2015.
2. Sudhakar, D. A., and Shyammohan S. Palli. *Network Analysis.* 4th ed., Tata McGraw Hill, 2018.
3. Theraja, B. L., and A. K. Theraja. *A Textbook of Electrical Technology.* 23rd ed., S. Chand Publishers, 2002.

Reference Books:

1. Hayt, William H., Jack E. Kemmerly, and Steven M. Durbin. *Engineering Circuit Analysis.* 9th ed., McGraw-Hill Higher Education, 2007.
2. Bimbra, P. S. *Electrical Machinery.* 7th ed., Khanna Publishers, 2000.

A9302 – Engineering Workshop

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

The Engineering Workshop course is designed to introduce students to basic and advanced manufacturing processes, workshop trades, and hands-on practical skills essential for engineering practice. The course provides experiential learning on a variety of trade skills including fitting, carpentry, welding, foundry, plumbing, electrical house wiring, and fabrication techniques such as 3D Printing. Students will gain practical familiarity with common tools, machines, and manufacturing methods, along with safety and quality management practices.

Course Pre/Co-requisites

This course has no specific pre-requisites and co-requisites.

Relevant Sustainable Development Goals (SDG(s))

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9302.1. Demonstrate the ability to perform fundamental workshop trades, including fitting, carpentry, welding, and plumbing, by completing a variety of hands-on tasks.

A9302.2. Demonstrate safe and effective usage of fabrication tools and digital equipment.

A9302.3. Identify and operate common workshop machines and tools while strictly adhering to safety protocols and quality management practices.

A9302.4. Recognize the properties of different materials and select appropriate tools and processes for specific manufacturing applications.

A9302.5. Fabricate a complete, functional assembly by integrating multiple skills learned across different workshop trades.

Course Syllabus

Part - A (Practical)

1. Fitting: L - Fit / V - Fit / Square - Fit / Semi Circular - Fit.
2. Carpentry: Lap Joint/ T- Bridle Joint / Mortise & Tenon Joint.
3. House wiring: Series / Parallel / One Bulb by One Switch / Tube Light / One Bulb by Two way Switch.
4. Welding: Butt Joint / Lap Joint / T Joint.
5. Foundry: Single Piece Pattern/ Split Piece Pattern / Multi Piece Pattern.
6. Tin Smithy: Open Scoop / Funnel / Rectangular Tray / Cylindrical.
7. Plumbing: Pipe Threading / Pipe Joints.
8. 3D Printing: Prepare a 3D Printing Model.

Part - B (Demonstration)

1. CNC Machining & Power Tools.
2. Casting & Plastic Moulding.
3. Welding (TIG/MIG, Gas Welding), Brazing.
4. Blacksmithy.

Laboratory Equipment/Software/Tools Required:

1. Fitting: Bench vise, Hacksaw frame, Calipers, Files, Try Square.
2. Carpentry: Carpentry vise, Chisels, Saws, Wooden Hammer, Try Square.
3. House Wiring: Voltage Tester, Wire Cutter, Wire Stripper, Cutting Plier, Nose Plier, Wire Gauge.
4. Welding: Welding M/c, Safeguards, Chipping Hammer, Electrode Holder.
5. Foundry: Wooden patterns, Riddle, Riser, Runner, Gate cutter, Rammers.
6. Tin Smithy: Wire Gauge, Snips, Pliers, Steel rule, Soldering kit, Spot Welding, Nylon Hammers.
7. Plumbing: Pipe Wrench, Pipe Cutter, Pliers, Pipe Die Set.
8. 3D Printing, 3D Modeling & Slicer Software.
9. Furnace, tongs, Swage Block.
10. Additional: Model Joints, Craft Knives and Electric Boards.

Books and Materials

Text Books:

1. Hajra Choudhury, S.K., and Nirjhar Rao. *Elements of Workshop Technology [Vol. 1, Manufacturing Processes]*, Revised and Enlarged 7th ed., Media Prompters & Publishers, 2023.
2. Singh, Devendra, et al. *Workshop Technology: Crafting Innovation for Engineering Students*, 1st ed., Redshine Publication, 2025.
3. Rosenberg, Neil. *Designing 3D Printers: Essential Knowledge*, 3rd ed., Independently published, 2023.

Reference Books:

1. Reddy, K. Venkata. *Workshop Practice Manual*, Reprint, 6th ed., BSP Books Private Ltd, 2025.
2. Gupta, Ram K. *3D Printing: Fundamentals to Emerging Applications*, 1st ed., CRC Press, 2024.
3. Devi, V. Lakshmi, and Kumar K. *Battery Technology Handbook: Classification, Control, and System Integration: Comprehensive Guide to EV Battery Design and Management Systems*, 1st ed., Notation Press, 2024.

A9021 - Community Centered Design Thinking

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	0	45	45	1	40	60	100

Course Description

Course Overview

The "Community-Centered Design Thinking" course aims to enable students to identify and address unique needs and challenges within local communities. Through the application of design thinking principles, students will develop creative problem-solving mindsets and the ability to collaborate effectively in multidisciplinary teams. The course emphasizes integrating moral code, professional standards, and sustainability principles into design solutions.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being
SDG 4: Quality Education
SDG 11: Sustainable Cities and Communities
SDG 17: Partnerships for the Goals

Course Outcomes

After the completion of the course, the student will be able to:

A9021.1. Apply the principles of design thinking, empathy, and sustainability to identify and understand real-world community challenges.

A9021.2. Conduct field research surveys and observation to define community-based problem statements.

A9021.3. Ideate creative solutions using appropriate tools and techniques to meet the identified community needs.

A9021.4. Collaborate with community members, NGOs, and peers to test, refine, and validate design solutions through feedback and co-design processes.

A9021.5. Communicate design outcomes effectively through documentation, storytelling, and ethical reflection considering accessibility, inclusivity, and life-cycle impact.

Course Syllabus

Unit-I:

Community-Centered Design Thinking: Understanding the significance of community-centered approaches, Overview of Design Thinking principles for community engagement.

Unit-II:

Needs and Challenges Assessment: Techniques for identifying and analyzing unique needs within local communities, SDGs Alignment, Case studies illustrating successful community-centered design projects.

Unit-III:

Research and Comparative Analysis for Innovation: Investigating existing solutions to community challenges, comparing their effectiveness, and identifying opportunities to create improved, innovative approaches.

Unit-IV:

Ethical Design and Sustainability: Integrating moral code and professional standards into the design process. Incorporating sustainability principles in design to define socially responsible solutions.

Unit-V:

Refine Problem Statement: study existing solutions, and generate creative, community-focused ideas, with all findings documented for the next stage of development.

Activity Plan

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
1	Unit-I: CCDT	Understand significance of community centered approaches	Concept Briefing + Discussion	Icebreaker: list visible community challenges	Reflection notes: "Why is community engagement critical?"	CO1
2	Unit-I: CCDT	Learn design thinking principles	Concept Briefing + Activity	Mini design thinking cycle for sample issue	Mind-map of 5 stages applied to local issue	CO1
3	Unit-II: Needs Assessment	Acquire techniques for identifying needs	Concept Briefing + Hands on Session	Practice mock interviews, empathy mapping	Conduct mini survey (3–5 people)	CO2
4	Unit-II: Needs Assessment	Connect needs to SDGs	Concept Briefing + Case Study	Group analysis: link issues to SDGs	Case study report (2–3 pages)	CO2
5	Unit-III: Research	Investigate existing solutions	Guided Research	Group research on 2–3 existing interventions	Summary table of solutions	CO3
6	Unit-III: Comparative Analysis	Compare effectiveness of solutions	Presentations	Present comparison of solutions (pros/cons)	Comparative chart submission	CO3
7	Unit-IV: Ethics	Integrate ethics into design	Debate	Debate: "Should cost outweigh ethics?"	Short essay on ethical dilemma	CO4
8	Unit-IV: Sustainability	Apply sustainability principles	Hands on Session	Create sustainability checklist for ideas	Submit checklist + reflection	CO4
9	Unit-V: Refinement	Refine problem statements	Guided Group Work	Rewrite into "How Might We..." questions	Final problem statement submission	CO2, CO5

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
10	Unit-V: Refinement	Study existing solutions deeply	Problem Statement Review	Critique and identify gaps in solutions	Gap Analysis Report	CO3, CO5
11	Unit-V: Ideation	Generate creative ideas	Ideation Hands-on Session	Brainstorming, SCAMPER, Story boarding	Sketches/story boards of top 3 ideas	CO3, CO5
12	Unit-V: Documentation & Presentation	Present and document findings	Final Showcase	Group presentations + reflection sharing	Final report + individual reflection essay	CO5

Books and Materials

Text Books:

1. Pavan Soni. *Design Your Thinking*, Penguin Random House India, New Delhi, 2020.
2. Anuja Agarwal. *Design Thinking: A Framework for Applying Design Thinking in Problem Solving*, Cengage India, 2024.

Reference Books:

1. Srinivasan R., Mohammed Ismail, Arulmozhi Srinivasan. *Design Thinking: Principles, Processes and Applications*, S Chand Publishing, 2025.

I B.Tech. II Semester

A9002 – Ordinary Differential Equations and Vector Calculus

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	15	0	60	120	4	40	60	100

Course Description

Course Overview

This course provides the fundamental mathematical concepts and techniques essential for engineering applications. In this course, the students are acquainted with ordinary differential equations of first and higher order and Laplace transforms, vector calculus. The course is designed to build conceptual clarity and problem-solving skills, with emphasis on both theoretical understanding and practical applications.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9002.1. Make use of first order differential equations to solve real world problems.

A9002.2. Solve ordinary differential equations of higher order.

A9002.3. Apply Laplace transforms to solve ordinary differential equations.

A9002.4. Determine divergence and curl of a vector point function.

A9002.5. Compute line, surface, and volume integrals and convert them into one another using appropriate theorems.

Course Syllabus

Unit-I:

First Order Ordinary Differential Equations: Exact differential equations, Equations reducible to exact differential equations, linear and Bernoulli's equations, Orthogonal Trajectories (only in Cartesian Coordinates). Applications: Newton's law of cooling, Law of natural growth and decay.

Unit-II:

Ordinary Differential Equations of Higher Order: Higher order linear differential equations with constant coefficients: Non-homogeneous terms of the type e^{ax}, $\sin ax$, $\cos ax$, polynomials in x, $e^{ax}V(x)$ and $xV(x)$, method of variation of parameters.

Unit-III:

Laplace Transforms: Laplace Transform of standard functions, First shifting theorem, Laplace transforms of functions multiplied by 't' and divided by 't', Laplace transforms of derivatives and integrals of function, Evaluation of integrals by Laplace transforms, Laplace transform of periodic functions, Inverse Laplace transform by different methods, convolution theorem (without proof). Applications: solving Initial value problems by Laplace Transform method.

Unit-IV:

Vector Differentiation: Vector point functions and scalar point functions, Gradient, Directional derivatives, Divergence and Curl, Vector Identities, Scalar potential functions, Solenoidal and Irrotational vectors.

Unit-V:

Vector Integration: Line integral, Surface integral and Volume Integral. Theorems of Green, Gauss and Stokes (without proofs) and their applications.

Books and Materials

Text Books:

1. Grewal, B. S. *Higher Engineering Mathematics*, 43rd ed., Khanna Publications, 2015.
2. Jain, R. K., Iyengar, S. R. K. *Advanced Engineering Mathematics*, 5th ed., Narosa Publishing House, 2016.

Reference Books:

1. Raisinghania M.D. *Ordinary and Partial Differential Equations* , 20th ed., S. Chand Publishing, 2024.
2. Greenberg Michael D.*Advanced Engineering Mathematics*, 2nd ed., Upper Saddle River, N.J. Prentice Hall, 1998.
3. Kreyszig, E. *Advanced Engineering Mathematics*, 9th ed., John Wiley & Sons, 2006.
4. Ramana, B. V. *Higher Engineering Mathematics*, 32nd edition reprint, McGraw Hill Education (India), 2018.

A9009 – Engineering Chemistry

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course emphasizes the application of chemical principles to analyse and address engineering problems, including water and its treatment for diverse purposes, the study of engineering materials such as plastics, fibres, elastomers, and composites, as well as non-conventional energy sources, batteries, and fuel cells. The course aims to integrate theoretical knowledge with practical applications, preparing students to evaluate and implement chemical solutions in engineering contexts.

Course Pre/Co-requisites

This course has no specific prerequisites and co requisites.

Relevant Sustainable Development Goals (SDGs)

SDG 6: Clean Water and Sanitation
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action

Course Outcomes

After the completion of the course, the student will be able to:

A9009.1. Analyse the hardness and other impurities present in the water for industrial and domestic applications.

A9009.2. Apply electrochemical principles to protect the metals from corrosion.

A9009.3. Illustrate the types of energy sources along with their characteristics and applications.

A9009.4. Differentiate the properties of various polymeric materials based on their structure and engineering applications.

A9009.5. Compare the materials to study various physical and chemical properties.

Course Syllabus

Unit-I:

Water and its treatment: Introduction – hardness of water – causes of hardness – types of hardness: temporary and permanent – expression and units of hardness, numerical problems. Steps involved in the treatment of potable water - disinfection of potable water by chlorination and break-point chlorination. Boiler troubles: sludges, scales and caustic embrittlement. Internal treatment of boiler feed water – Calgon conditioning – Phosphate conditioning – Colloidal conditioning – softening of water by ion exchange processes. Desalination of water – Reverse osmosis.

Unit-II:

Electrochemistry and Corrosion: Introduction- Electrode potential, standard electrode potential, Nernst equation (no derivation), electrochemical cell - Galvanic cell, cell representation, EMF of cell - numerical problems. Types of electrodes, reference electrodes - primary reference electrode - standard Hydrogen Electrode (SHE), Secondary reference electrode - Calomel electrode. Construction, working and determination of pH of an unknown solution using SHE and Calomel electrode.

Corrosion: Introduction- definition, causes and effects of corrosion – theories of corrosion, chemical and electrochemical theories of corrosion, Types of corrosion: galvanic, water-line and pitting corrosion. Factors affecting rate of corrosion - nature of the metal, nature of the corroding environment. Corrosion control methods - electroplating, electroless plating and metal cladding.

Unit-III:

Energy Sources:

Batteries: Introduction – Classification of batteries - Primary, secondary and reserve batteries with examples. Construction, working and applications of Lead acid battery and Lithium ion battery. Fuel Cells – differences between a battery and a fuel cell, construction and applications of Hydrogen-Oxygen fuel cell.

Fuels: Introduction and characteristics of a good fuel, Calorific value – Units - HCV, LCV- Dulongs formula - Numerical problems. *Fossil fuels:* Introduction, Classification, Petroleum - Refining of Crude oil, Cracking - Types of cracking - Moving bed catalytic cracking. LPG and CNG composition and use. *Synthetic Fuels:* Fischer-Tropsch process, Introduction and applications of Hythane and Green Hydrogen.

Unit-IV:

Polymeric Materials: Terminology, types of polymerization – addition and condensation polymerization with examples. Plastics: Thermoplastic resins & Thermosetting resins. Preparation, properties and engineering applications of Polyvinyl chloride and Teflon. Fibers: Preparation, properties and engineering applications of Nylon-6,6 and Dacron. Elastomers: Natural rubber and its vulcanization, artificial rubbers - Buna-S and Butyl rubber. Conducting Polymers: classification, mechanism of conduction in trans - polyacetylene – applications. Biodegradable polymers: Polylactic acid and its applications.

Unit-V:

Advanced Functional Materials:

Graphene: Isolation, Structure and strength, applications in Computer, Electrical and Electronic Devices.

Smart materials: Introduction, Classification with examples - Shape Memory Alloys – Nitinol, Piezoelectric materials – quartz and their engineering applications. Biosensor - Definition, Amperometric Glucose monitor sensor.

Portland cement: Chemical constituents, Setting and Hardening and applications of cement.

Books and Materials

Text Books:

1. Rama Devi, B., Aparna, P., and Prasanta Rath. *Engineering Chemistry.* 2nd ed., Cengage Publications, 2025.
2. Jain, Jain. *Engineering Chemistry.* 16th ed., Dhanpat Rai Publication Company, 2015.

Reference Books:

1. Agarwal, Shikha. *Engineering Chemistry.* Cambridge University Press, Delhi, 2015.
2. Chawla, Shashi. *Engineering Chemistry.* Dhanpat Rai and Company (P) Ltd., Delhi, 2011.
3. Thirumala Chary, M., E. Laxminarayana, and K. Shashikala. *A Textbook of Engineering Chemistry.* Pearson Publications, 2021.
4. Singh, Paramvir, Avinash Kumar Agarwal, Anupma Thakur, and R. K. Sinha. *Challenges and Opportunities in Green Hydrogen.* Springer, 2024.
5. Leo, Donald J. *Engineering Analysis of Smart Material Systems.* John Wiley & Sons, 2007.
6. *E-book:* "Engineering Chemistry by Shashi Chawla." Internet Archive, https://archive.org/details/EngineeringChemistryByShashiChawla/page/n11/mode/2up.

A9011 – English for Skill Enhancement

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
30	0	0	30	60	2	40	60	100

Course Description

Course Overview

This course has been designed to develop linguistic and communicative competencies among engineering students. The Reading and Writing skills of the students are honed during the sessions using the prescribed textbook. Additionally, students are trained on effective usage of grammar and vocabulary. Further, they are encouraged to read texts which are aimed at developing their comprehension skills.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 17: Partnerships for the Goals

Course Outcomes

After the completion of the course, the student will be able to:

A9011.1. Identify and use appropriate vocabulary to compose and deliver clear oral and written communication
A9011.2. Practice adept usage of grammar for effective communication
A9011.3. Interpret and summarize known and unknown passages
A9011.4. Develop proficiency in writing for academic purposes
A9011.5. Demonstrate basic proficiency in professional correspondence

Course Syllabus

Unit-I:

Theme: Perspectives
Text: Lesson on 'The Generation Gap' by Benjamin M. Spock
Vocabulary: Word Formation - Prefixes and Suffixes; Synonyms and Antonyms
Grammar: Identifying Common Errors in Writing with reference to Articles and Prepositions, Conjunctions
Reading: Reading and its importance - Sub skills of Reading – Skimming and Scanning
Writing: Sentence Structures - Use of Phrases and Clauses in Sentences - Types of Sentences; Punctuation; Techniques for Writing precisely – Paragraph Writing – Types, Structures and Features of a Paragraph – Creating Coherence - Organizing Principles of Paragraphs in Documents

Unit-II:

Theme: Digital Transformation
Text: Lesson on 'Emerging Technologies'
Vocabulary: Homophones, Homonyms and Homographs
Grammar: Identifying Common Errors in Writing with reference to Tenses, Noun-Pronoun Agreement and Subject-Verb Agreement
Reading: Reading Strategies - Guessing Meaning from Context – Identifying Main Ideas - Exercises for Practice
Writing: Essay writing.

Unit-III:
Theme: Attitude and Gratitude
Text: Poems on 'Leisure' by William Henry Davies and 'Be Thankful' – Unknown Author
Vocabulary: Words often Confused; Phrasal Verbs
Grammar: Misplaced Modifiers
Reading: Sub-Skills of Reading – Identifying Topic Sentence and Providing Supporting Ideas - Exercises for Practice
Writing: Letter Writing: Letter of Request, Letter of Inquiry, Letter of Apology, Letter of Complaint, Email writing - Format, Style and Etiquette.

Unit-IV:
Theme: Entrepreneurship
Text: Lesson on 'Why a Start-up Needs to Find its Customers First' by Pranav Jain
Vocabulary: Standard Abbreviations in English, Idioms
Grammar: Redundancies in Oral and Written Communication, Transformation of sentences - Active and Passive Voice
Reading: Prompt Engineering Techniques – Comprehending and Generating Appropriate Prompts - Exercises for Practice
Writing: Precis Writing; Writing a Letter of Application and Resume/CV.

Unit-V:
Theme: Integrity and Professionalism
Text: Lesson on 'Professional Ethics'
Vocabulary: Technical Vocabulary and its Usage, Collocations
Grammar: Transformation of sentences - Reported Speech, Common Errors covering all other aspects of grammar
Reading: Survey, Question, Read, Recite and Review (SQ3R Method) – Inferring the Meaning and Evaluating a Text - Exercises for Practice
Writing: Technical Reports - Introduction – Characteristics of a Report - Structure of Report (Manuscript Format)

Books and Materials

Text Books:

1. Board of Editors, *English for the Young in the Digital World.* Orient Black Swan Pvt. Ltd. 2025.

Reference Books:

1. Swan, Michael, *Practical English Usage.* Oxford University Press. New Edition, 2016.
2. Karal, Rajeevan, *English Grammar Just for You.* Oxford University Press. New Delhi, 2023.
3. Cengage India, *Empowering with Language: Communicative English for Undergraduates.* Cengage Learning India Pvt. Ltd. New Delhi, 2024.
4. Sanjay Kumar & Pushp Lata, *Communication Skills – A Workbook.* Oxford University Press. New Delhi, 2022.
5. Wood, F.T., *Remedial English Grammar.* Macmillan, 2007.
6. Vishwamohan, Aysha. *English for Technical Communication for Engineering Students.* McGraw-Hill Education India Pvt. Ltd, 2013.

A9503 – Data Structures

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces C++ programming with a focus on designing and implementing data structures. It covers object-oriented concepts such as classes, encapsulation, and abstraction for modular programming. Students learn to use pointers and dynamic memory for efficient data management. Templates and the Standard Template Library (STL) are taught for generic and reusable code. Linked lists are explored for dynamic data storage and sequential operations. Stacks and queues are implemented for practical applications like expression evaluation and task management. Tree structures are studied to represent hierarchical data with traversal and search methods. Binary search trees and AVL trees are covered to ensure organized and balanced data storage. Graph concepts and algorithms are introduced to model and navigate complex relationships. Hashing and dictionary structures provide fast data retrieval and efficient storage solutions. The course emphasizes hands-on programming to reinforce theoretical concepts. By the end, students can design, implement, and analyze core data structures effectively in C++.

Course Pre/Co-requisites

A9501 – Programming for Problem Solving

A9502 – Programming for Problem Solving Laboratory

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9503.1. Make use of programming constructs, Templates and STL components to implement data structures and solve computational problems effectively.

A9503.2. Implement linked list data structures using abstract data types to perform various operations.

A9503.3. Implement stack and queue abstract data types for solving applications on linear data.

A9503.4. Choose an appropriate nonlinear data structure for representing and solving real world problems.

A9503.5. Examine hashing and dictionary structures for insertion, deletion, and searching in computational problems.

Course Syllabus

Unit-I:

Introduction to C++ and Data Structures: Structure of a C++ Program, Classes and objects, Dynamic memory allocation (new and delete), Constructors and destructors, Access specifiers (public, private), Encapsulation and abstraction, Pointers and references, Functions, Inline functions, and function overloading. Template Definition, Function Templates, class Templates, Generic Function, Template function Overloading. Standard Template Library (STL) Overview- Containers: vector, list, map, set. Iterators and algorithms, Using STL templates in practical applications.

Unit-II:

Linked Lists: Classification of Data Structures, Abstract Data Types, Introduction to Linked Lists, Applications of Linked Lists, Node Structure and Memory Allocation. Linked List ADT, Singly Linked List Operations-Insert, Delete, Search and Traverse. Doubly Linked List Operations – Insert, Delete, Search and Traverse and Circular Linked Lists.

Unit-III:

Stacks and Queues: Stack ADT – Concepts and Applications. Array and Linked List implementation of Stacks. Applications – Conversion of Expression from infix to postfix, Evaluation of Postfix Expression. Queue ADT – Concepts & Applications. Array and Linked List implementation of Linear Queues, Array Implementation of Circular Queue and Double Ended Queue.

Unit-IV:

Trees and Graphs: Tree ADT, Binary Tree Terminology and Properties, Binary Tree Traversals – Inorder, Preorder and Postorder. Binary Search Tree Operations – Insertion, Deletion and Searching. AVL Trees, Definition, Height of an AVL Tree, Operations – Insertion, Deletion and Searching. Graph Definitions and Terminology. Graph Representations – Adjacency Matrix and Adjacency List. Graph Traversals – Depth-First Search (DFS) and Breadth-First Search (BFS).

Unit-V:

Dictionaries and Hashing: Hash Table Representation: hash functions, collision resolution-separate chaining, open addressing, linear probing, quadratic probing, double hashing, rehashing, extendible hashing. Dictionaries-linear list representation, skip list representation, operations - insertion, deletion and searching.

Books and Materials

Text Books:

1. Horowitz, Ellis, Sartaj Sahni, and Dinesh Mehta. *Fundamentals of Data Structures in C++*, 2nd ed., Universities Press, 2019.
2. Horowitz, *Data Structures Using C++*, 3rd edition, Course Technology, 2010.

Reference Books:

1. Drozdek, Adam. *Data Structures and Algorithms in C++*, 5th ed., Cengage Learning, 2025.
2. Dale, Nell, Chip Weems, and Tim Richards. *C++ Plus Data Structures*, 6th ed., Jones & Bartlett Learning, 2018.

A9403 – Electronic Devices and Circuits

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course covers fundamental topics that are central to a wide range of electronic devices and circuits. It begins with the origin and evolution of semiconductor devices and progresses toward their practical applications. The course introduces the structure, operation, and characteristics of key semiconductor components such as PN junction diodes, Zener diodes, BJTs, JFETs, and MOSFETs. It further explores BJT biasing techniques, transistor amplifier analysis using small-signal models, and rectifier circuits with filtering. Additionally, the course includes nonlinear applications like clippers and clampers and extends into advanced nanoelectronic devices such as FinFETs and CNTFETs. Through a blend of theoretical concepts and practical insights, the course lays a strong foundation for students to pursue advanced study and research in various domains of semiconductor devices and electronic circuit design.

Course Pre/Co-requisites

A9007 – Engineering Physics

A9202 – Principles of Electrical Engineering

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9403.1. Demonstrate the operation and characteristics of diodes and bipolar transistors under various biasing conditions.

A9403.2. Make use of rectifier, filter, and regulator circuits to design DC regulated power supply.

A9403.3. Analyze biasing circuits for stable operation of transistors.

A9403.4. Analyze single stage transistor amplifier circuits using low frequency h-parameter mode.

A9403.5. Illustrate the operation and characteristics of JFET, MOSFET, FinFET and CNTFET under various conditions.

Course Syllabus

Unit-I:

Diode Characteristics: Current-voltage characteristics of PN-junction diode, diode resistance and capacitance, diode models and I-V characteristics of Zener diode. **Diode Applications:** Fullwave rectifier (center-tapped and bridge), rectifier with capacitor filter, clippers and clampers, Zener diode as a voltage regulator.

Unit-II:

Bipolar Junction Transistor (BJT): Structure and working principle of BJT, current components and transistor action, transistor configurations, input and output characteristics, determination of h-parameters from transistor characteristics.

Unit-III:

BJT Biasing: Need for biasing and stabilization, load line and operating point, Biasing techniques: fixed bias, collector to base bias and voltage divider bias, condition for thermal stability.

Unit-IV:

Transistor Amplifiers: Transistor as a small-signal amplifier, h-parameter model, analysis of transistor amplifier using exact h-parameter model (CE, CB and CC), approximate or simplified CE model, analysis of transistor amplifier using approximate h-parameter model (CE and CE with unbypassed R_E).

Unit-V:

Field Effect Transistors: JFET: Structure, operation, and characteristics, MOSFET: Enhancement and Depletion modes – Structure, operation, and characteristics, Advanced Devices: FinFETs - 3D structure, scaling advantages, CNTFETs - Structure, ballistic transport, fabrication, Comparison: CMOS vs. FinFET vs. CNTFET.

Books and Materials

Text Books:

1. Millman, Jacob, and Christos C. Halkias. *Electronic Devices and Circuits.* Tata McGraw-Hill, 1991.
2. Boylestad, Robert L., and Louis Nashelsky. *Electronic Devices and Circuit Theory.* 11th ed., PHI Learning, 2013.
3. Sedra, Adel S., and Kenneth C. Smith. *Microelectronic Circuits.* 7th ed., Oxford University Press, 2014.

Reference Books:

1. Bell, David A. *Electronic Devices and Circuits.* Oxford University Press, 5th ed., 2008.
2. Neamen, Donald A. *Electronic Circuit Analysis and Design.* McGraw-Hill, 2nd ed., 2001.
3. Salivahanan, S., and N. Suresh Kumar. *Electronic Devices and Circuits.* McGraw-Hill Education, 4th ed., 2017.
4. Razavi, Behzad. *Fundamentals of Microelectronics.* Wiley, 2nd ed., 2013.
5. Taur, Yuan, and Tak H. Ning. Fundamentals of Modern VLSI Devices. Cambridge University Press, 2nd ed., 2009.

A9010 – Engineering Chemistry Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

The Engineering Chemistry Laboratory equips students with practical skills essential for understanding the chemical principles behind engineering materials and processes. It bridges theoretical knowledge with real-world applications, fostering analytical thinking and precision. Students learn to handle instruments, analyze data, and interpret results relevant to industrial and environmental contexts. The course emphasizes the role of chemistry in addressing engineering challenges and societal needs. Overall, it builds a strong foundation for innovation and responsible technological development.

Course Pre/Co-requisites

This course has no specific prerequisites and co requisites.

Relevant Sustainable Development Goals (SDGs)

SDG 6: Clean Water and Sanitation
SDG 12: Responsible Consumption and Production
SDG 13: Climate Action

Course Outcomes

After the completion of the course, the student will be able to:

A9010.1. Apply the instrumental techniques to find out the strength of solutions.
A9010.2. Analyze the impurities present in the water using volumetric analysis.
A9010.3. Make use of different titrimetric methods to measure chemical species.
A9010.4. Analyze the importance of temperature and pressure on physical properties of liquids.
A9010.5. Calculate the yield of synthesized compounds by maintaining appropriate reaction conditions.

Course Syllabus

List of Experiments:

1. Estimation of amount of ferrous ion in the given solution by permanganometry.
2. Estimation of hardness of water by complexometry using EDTA.
3. Estimation of amount of hydrochloric acid in the given solution by conductometry.
4. Estimation of amount of strong and weak acid in the given solution by conductometry.
5. Estimation of amount of hydrochloric acid in the given solution by potentiometry.
6. Estimation of amount of ferrous ion in the given solution using potassium permanganate by potentiometry.
7. Estimation of manganese ion in the given solution by colorimetry.
8. Estimation of Copper ion in the given solution by colorimetry.
9. Determination of viscosity of the given liquid by Ostwald's viscometer.
10. Determination of surface tension of the given liquid by using stalagmometer.

11. Preparation of Bakelite.
12. Preparation of Nylon 6,6.

Laboratory Equipment/Software/Tools Required:

1. Digital Conductometer
2. Digital Potentiometer
3. Digital Colorimeter
4. Electrical Water Heater
5. Wall Mount Distillation Plant
6. Analytical/Digital Weighing Balance
7. Ostwald's Viscometer
8. Stalagmometer
9. Stopwatch
10. Thermometer
11. RB Flask condenser
12. Magnetic Stirrer
13. Pipette
14. Burette
15. Beaker

Books and Materials

Text Books:

1. Rama Devi, B., Aparna, P., and Prasanta Rath. *Engineering Chemistry.* 2nd ed., Cengage Publications, 2025.

Reference Books:

1. Vogel, A. I. *Inorganic Quantitative Analysis.* ELBS Publications.
2. Ahluwalia, V. K. *College Practical Chemistry.* Narosa Publications Ltd., 2007

A9012 – English Language and Communication Skills Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course is designed to cater to the needs of students in developing their oral communication skills. It begins with an introduction to Phonetics to make them understand the received pronunciation and to help them speak with a neutral accent. This course incorporates listening skills and draws exercises of listening comprehension from various general and business contexts. The speaking exercises in this course will help the students to present their ideas in different situations, besides helping them to develop team spirit by participating in pair/group activities.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 17: Partnerships for the Goals

Course Outcomes

After the completion of the course, the student will be able to:

A9012.1. Acquire the received pronunciation and speak in a neutral accent
A9012.2. Use language effectively in real-life situations
A9012.3. Demonstrate effective use of non verbal communication
A9012.4. Interpret visual data for oral communication
A9012.5. Develop the ability to enhance listening skills

Course Syllabus

List of Experiments:

1. CALL Lab:

Instruction: Speech Sounds - Listening Skills - Listening vs. Hearing - Importance – Purpose - Types
Practice: Listening to Distinguish Speech Sounds (Minimal Pairs) - Testing Exercises

2. ICS Lab:

Diagnostic Test: Activity titled 'Express Your View'
Instruction: Spoken and Written language - Formal and Informal English - Greetings – Introducing Oneself and Others
Practice: Any Ice-Breaking Activity

3. CALL Lab

Instruction: Barriers to Listening - Active Listening
Practice: Listening for General Information - Multiple Choice Questions - Listening Comprehension - Exercises for practice

4. ICS Lab:
Instruction: Features of Good Conversation – Strategies for Effective Communication
Practice: Role Play Activity - Situational Dialogues – Expressions used in Various Situations – Making Requests and Seeking Permissions – Taking Leave - Telephone Etiquette

5. CALL Lab
Instruction: Minimizing Errors in Pronunciation (MTI)
Practice: Differences between British and American Pronunciation – Listening Comprehension – Exercises for practice

6. ICS Lab:
Instruction: Describing Objects, Situations, Places, People and Events
Practice: Picture Description Activity – Looking at a Picture and Describing Objects, Situations, Places, People and Events

7. CALL Lab:
Instruction: Techniques for Effective Listening
Practice: Listening for Specific Details - Listening - Gap Fill Exercises - Listening Comprehension – Exercises for practice

8. ICS Lab:
Instruction: Information transfer - oral interpretation of graphical data
Practice: Activity on oral interpretation of graphical data

9. CALL Lab:
Instruction: Identifying the literal and implied meaning
Practice: Listening for Evaluation - Write the Summary – Listening Comprehension – Exercises for practice

10. ICS Lab:
Instruction: Understanding Non-Verbal Communication
Practice: Dumb Charades Activity
Post-Assessment Test: 'Express Your View'

Laboratory Equipment/Software/Tools Required:

1. Computers with internet
2. K VAN Solutions Software
3. Headphones
4. Audio Visual Equipment
5. Camcorder

Books and Materials

Lab Manual:

1. Laboratory Handbook on English Language and Communication Skills Lab.

Reference Books:

1. Brook-Hart, Guy. *Cambridge English Business Benchmark - Upper Intermediate Business Vantage (with CD)*, 2nd Edition, South Asian Edition, Cambridge University Press, 2019.
2. Shobha, KN & Rayen, J. Lourdes. *Communicative English – A workbook.* Cambridge University Press, 2019.
3. Board of Editors. *ELCS Lab Manual: A Workbook for CALL and ICS Lab Activities.* Orient BlackSwan Pvt. Ltd. , 2016.
4. Mishra, Veerendra et al. *English Language Skills: A Practical Approach.* Cambridge University Press, 2020.
5. *English Language Communication Skills – Lab Manual cum Workbook.* Cengage Learning India Pvt. Ltd.
6. Ur, Penny and Wright, Andrew. *Five Minute Activities – A Resource Book for Language Teachers.* Cambridge University Press, 2022.
7. *TOEFL & GRE (KAPLAN, AARCO & BARRONS, USA, Cracking GRE by CLIFFS).*

A9504 – Data Structures Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course enables to design and implement efficient C++ programs. Students learn object-oriented concepts such as classes, objects, and dynamic memory. It covers data structures including arrays, linked lists, stacks, queues, trees, and graphs. Hands-on exercises emphasize insertion, deletion, traversal, and searching operations. Students explore algorithms to improve performance and optimize data handling. Practical work with STL containers, iterators, and templates is included. Hashing and dictionary implementations demonstrate efficient data retrieval techniques. The course develops analytical thinking and systematic problem-solving skills. Students gain experience in building reliable, maintainable, and scalable software. By the end, students can apply programming concepts to solve real-world computational problems.

Course Pre/Co-requisites

A9501 – Programming for Problem Solving

A9502 – Programming for Problem Solving Laboratory

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9504.1. Implement programs that efficiently manage and manipulate data using dynamic programming techniques in C++.

A9504.2. Apply various linked list techniques to perform insertion, deletion and traversal on given data.

A9504.3. Develop programs using linear data structures stack and queue to handle data processing tasks efficiently.

A9504.4. Implement nonlinear data structures to solve real time aplications.

A9504.5. Choose appropriate hashing and dictionary methods to efficiently store, retrieve, and manipulate data.

Course Syllabus

List of Experiments:

1. Implementing Classes, Objects, and Dynamic Memory Allocation
   a. Define a Student class with attributes: rollNumber, name, marks
   b. Implement a constructor to initialize objects and a destructor to display a message when an object is deleted
   c. Dynamically allocate an array of Student objects using new
   d. Input details of n students and display them
   e. Release allocated memory using delete

2. Function Overloading and Templates
   a. Implement two overloaded functions add() that can add:Two integers, Two floating-point numbers
   b. Define a function template swapValues() that swaps two variables of any type.
   c. Test swapValues() with integer, float, and string types
3. Using STL Containers and Iterators
   a. Create a vector of integers, insert elements, and display them using an iterator
   b. Create a list of strings, perform insertion and deletion, and traverse using an iterator
   c. Use a map to store StudentID -> Name pairs and display all elements
   d. Use a set to store unique integers and print them in sorted order
   e. Apply STL algorithms like sort(), find(), and count() on the containers
4. Implementing Singly Linked List (ADT) Operations
   a. Define a Node structure containing data and a next pointer Implement functions to:
   b. Insert a node at the beginning, end, and at a given position
   c. Delete a node from the beginning, end, and a specified position..
   d. Traverse the linked list and display all elements
   e. Search for an element in the list and return its position.
   f. Demonstrate all operations with sample inputs
5. Implementing Doubly Linked List (ADT) Operations
   a. Define a DoublyNode structure containing data, prev, and next pointers. Implement functions to:
   b. Insert a node at the beginning, end, and any position
   c. Delete a node from the beginning, end, and a specified position
   d. Traverse the list forward and backward
   e. Search for an element in the list.
   f. Demonstrate all operations with sample inputs
6. Circular Linked Lists (ADT) Operations
   a. Define a Node structure for circular singly linked lists with a next pointer pointing to the first node. Implement functions to:
   b. Insert a node at the beginning and end
   c. Delete a node from the beginning and end
   d. Traverse the list starting from any node and print all elements.
   e. Extend the above to circular doubly linked lists with prev and next pointers
   f. Demonstrate operations with sample inputs.
7. Implementing Stack (ADT) Using Array and Linked Lists Implement the following operations:
   a. push() – insert an element onto the stack
   b. pop() – remove the top element from the stack
   c. peek() – view the top element without removing it
   d. isEmpty() and isFull() – check stack status
8. Expression Conversion and Evaluation Using Stack
   a. Implement infix to postfix conversion using a stack
   b. Implement evaluation of postfix expressions using a stack
   c. Test with different arithmetic expressions (including parentheses)

9. Implementing Queues (ADT) Using Array and Linked Lists Implement a linear queue using:
    a. Array with enqueue() and dequeue() operations
    b. Linked list dynamically allocating nodes for each element
    c. Display or traverse list using array and linked list
10. Implementing Queues (ADT) Using Circular Linear List Implement a linear queue using:
    a. Array with enqueue() and dequeue() operations.
    b. Display or traverse list using array.
11. Binary Tree (ADT) Implementation and Traversals
    a. Define a Node structure with data, left, and right pointers. Implement functions to:
    b. Insert nodes into a binary tree
    c. Traverse the tree using:
    d. Inorder Traversal
    e. Preorder Traversal
    f. Postorder Traversal
    g. Demonstrate traversal operations with a sample binary tree
12. Binary Search Tree (BST) and AVL Tree Operations Implement BST operations:
    a. Insert a node
    b. Delete a node
    c. Search for a value
    d. Display the tree using Inorder traversal to verify correctness
13. AVL Tree Operations Implement BST operations:
    a. Insert a node
    b. Delete a node
    c. Search for a value
    d. Implement AVL tree insertion and deletion with rotations to maintain balance
    e. Display the tree using Inorder traversal to verify correctness
14. Hash Table Implementation and Collision Handling
    a. Implement a hash table using an array
    b. Design and apply a simple hash function
    c. Implement collision resolution techniques: Separate Chaining using linked lists Open Addressing: linear probing, quadratic probing, and double hashing
    d. Perform insertion, deletion, and searching operations.
    e. Demonstrate handling of collisions with sample inputs.
15. Dictionary Implementation Using Linear List and Skip List
    a. Implement a dictionary using a linear list: Perform insertion, deletion, and search operations.
    b. Implement a dictionary using a skip list for faster search: Include multiple levels with forward pointers. Implement insertion, deletion, and search.
    c. Compare the efficiency of linear list and skip list implementations with sample data order

Laboratory Equipment/Software/Tools Required:

1. Computer Systems (PCs) installed with Ubuntu OS (Open source/ Freeware)
2. GCC Compiler (Open source/ Freeware)

Books and Materials

Text Books:

1. Horowitz, Ellis, Sartaj Sahni, and Dinesh Mehta. *Fundamentals of Data Structures in C++*, 2nd ed., Schaum's Outlines, Universities Press, 2019.
2. Malik D.S.*Data Structures and Algorithms in C++.* , 5th ed., Course Technology, 2010.

Reference Books:

1. Drozdek, Adam. *Data Structures and Algorithms in C++.* , 5th ed., Cengage Learning, 2025.
2. Dale, Nell, Chip Weems, and Tim Richards. *C++ Plus Data Structures.*, 6th ed., Jones & Bartlett Learning, 2018.

A9304 - Computer Aided Engineering Graphics

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course provides students from diverse engineering disciplines with essential skills in computer-aided engineering drawing using AutoCAD. It focuses on the fundamentals of constructing two-dimensional geometric objects, understanding orthographic projections of points, lines, planes, and solids, and applying isometric projections. Students will learn to use AutoCAD tools such as Draw, Modify, Layers, and Dimensioning to create technically accurate drawings aligned with engineering standards. The course emphasizes practical applications relevant to civil, electrical, electronics, and other engineering fields, enabling students to visualize, interpret, and communicate design concepts effectively.

Course Pre/Co-requisites

This course has no specific pre-requisites and co-requisites.

Relevant Sustainable Development Goals (SDG(s))

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9304.1. Analyze the basic drawing and editing tools to create and modify 2D sketches.

A9304.2. Interpret the projection principles to draw points and lines in different quadrants.

A9304.3. Compare the projected views of planes to identify their true shape and inclination.

A9304.4. Apply the orthographic projection principles to construct two-dimensional views of solids.

A9304.5. Construct isometric views by applying principles derived from orthographic drawings.

Course Syllabus

Unit-I:

Introduction to AutoCAD: User Interface and Workspace Customization, Basic Drawing Tools, Modify and Editing Tools, Properties and Object Management, Layer Management, Dimensioning and Annotation, Layouts and Plotting, Geometrical construction of two-dimensional objects.

Unit-II:

Orthographic Projections: Reference plane, importance of reference lines or Plane, Projections of a point situated in any one of the four quadrants. Projections of Straight Lines: Projections of straight lines parallel to both reference planes, perpendicular to one reference plane and parallel to other reference plane, inclined to one reference plane and parallel to the other reference plane.

Unit-III:

Projections of Planes: Regular planes Perpendicular to both reference planes, parallel to one reference plane and inclined to the other reference plane; plane inclined to both the reference planes.

Unit-IV:

Projections of Solids: Types of solids: Polyhedra and Solids of revolution. Projections of solids in simple positions: Axis perpendicular to horizontal plane, Axis perpendicular to vertical plane and Axis parallel to both the reference planes, Projection of Solids with axis inclined to one reference plane and parallel to another plane.

Unit-V:

Isometric Projections: Isometric coordinates, Isometric Scale, Isometric Views of Lines, Planes and solids. Conversion of Isometric View to Orthographic View and Vice-versa.

Books and Materials

Text Books:

1. Bhatt N.D., Panchal V.M. & Ingle P.R., *Engineering Drawing*, 53rd Edition, Charotar Publishing House, 2019.
2. K. Balaveera Reddy et al, *Computer Aided Engineering Drawing*, 2nd Edition, CBS Publications, 2015.

Reference Books:

1. Narayana, K.L. & P Kannaiah, *Text book on Engineering Drawing*, 3rd Edition, Sci-Tech Publishers, 2020.
2. Basant Agrawal B. and Agrawal C. M., *Engineering Graphics*, 3rd Edition, TMH Publication, 2020.
3. Shah, M.B., Rana B.C., *Engineering Drawing and Computer Graphics*, 2nd Edition, Pearson Education, 2009.

A9022 - Product Design and Development

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	0	45	45	1	40	60	100

Course Description

Course Overview

This course equips students with a community-focused approach to product design, taking them from initial concept to a refined, practical solution. They will learn core design principles, understand the product development life cycle, and explore essential hardware and software tools through curated resources. Students will engage in prototyping, testing, and iterative refinement using feedback from community partners, ensuring sustainability and user-centered results. The course also develops their ability to document and communicate designs effectively, including preparing detailed specifications and user manuals.

Course Pre/Co-requisites

A9021 - Community Centered Design Thinking

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities
SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9022.1. Explain the principles of product design and the product development life cycle, with an emphasis on addressing real-world community needs

A9022.2. Generate and evaluate innovative product concepts using relevant Hardware and Software design tools

A9022.3. Develop functional prototypes using appropriate prototyping tools, and perform initial testing and validation

A9022.4. Refine prototypes through iterative feedback loops, integrating sustainability and user-centered design principles

A9022.5. Document and communicate product designs effectively with comprehensive specifications and user manuals tailored for community stakeholders

Course Syllabus

Unit-I:

Introduction to Product Design for Community Need: Understanding the principles and significance of product design, product development life cycle. Communicating design concepts to community partner. Refining designs based on feedback.

Unit-II:

Product Development Skills: Identify & Develop proficiency in using relevant Hardware & Software design tools. Equip with curated resources on tools essential for managing and scaling products effectively.

Unit-III:

Prototype & Testing: Introducing the concepts and purpose of prototyping. Creating functional prototypes to represent product designs using appropriate tools and techniques. Testing prototypes for performance, usability, and alignment with design goals.

Unit-IV:

Iterative Refinement: Refinement of prototypes based on community partner feedback and verification of product sustainability, with integration of user-centered design principles to align with community needs and expectations.

Unit-V:

Documentation and Communication Strategies: Documenting product designs with detailed specifications, Effective communication strategies for conveying designs to community partners, Preparation of user manuals and documentation for community partners.

Activity Plan

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
1	Unit-I: Intro to Product Design	Understand product design principles & life cycle	Concept briefing	Case study analysis of successful community-based product	Short reflection: "Importance of product design for communities"	CO1
2	Unit-I: Intro to Product Design	Identify community needs & build empathy	Concept briefing + Fieldwork preparation	Practice empathy mapping, mock survey in class	Conduct 3–5 interviews/surveys with stakeholders	CO1, CO2
3	Unit-I: Intro to Product Design	Define problem statements	Guided teamwork + Brainstorm session	Develop "How Might We" questions, prioritize opportunities	Submit refined problem statement document	CO1, CO2
4	Unit-II: Product Development Skills	Generate diverse concepts	Creativity Hands-on Session (SCAMPER, Role-storming)	Group ideation, sketching concepts	Sketchbook submission (min. 10 ideas)	CO2
5	Unit-II: Product Development Skills	Apply digital design tools	Hands-on training + Peer support	Practice in Figma / SolidWorks / TinkerCAD	Submit wireframes / 3D sketches	CO2
6	Unit-II: Product Development Skills	Evaluate concepts systematically	Evaluation + User testing demo	Apply Pugh method to concepts, gather peer feedback	Submit evaluation matrix + selected final concept	CO2, CO3

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
7	Unit-III: Prototype & Testing	Build low-fidelity prototype	Practical lab session + Peer feedback	Teams construct basic prototypes from cardboard/foam	Submit prototype photos + reflection	CO3
8	Unit-III: Prototype & Testing	Develop high-fidelity prototype	Prototype building - Hands-on Session	Create working model with core functionality	Submit tested prototype (video evidence optional)	CO3
9	Unit-IV: Iterative Refinement	Collect & apply user/community feedback	User feedback roundtable	Usability testing with peers/partners	Submit iteration log with design changes	CO4
10	Unit-IV: Iterative Refinement	Refine based on sustainability & ergonomics	Fine-tuning activity	Refine materials, safety, visual design, ergonomics	Submit refined prototype design brief	CO4
11	Unit-V: Documentation	Document & communicate design	Documentation + Visual design session	Create instruction guides, packaging design, visuals	Draft user manual (Canva/InDesign optional)	CO5
12	Unit-V: Communication Strategies	Present & reflect on outcomes	Final Showcase	Final presentations: video demos, posters, product showcase	Final report, user manual, and presentation	CO5

Books and Materials

Text Books:

1. Pavan Soni. *Design Your Thinking: The Mindsets, Toolsets and Skill Sets for Creative Problem-solving*, Penguin Random House India, 2024.
2. Anuja Agarwal. *Design Thinking: A Framework for Applying Design Thinking in Problem Solving*, Cengage India, 2024.

Reference Books:

1. Shalini Rahul Tiwari, Rohit Rajendra Swarup. *Design Thinking: A Comprehensive Textbook*, Wiley India, 2023.
2. Srinivasan R., Mohammed Ismail, Arulmozhi Srinivasan. *A Textbook on Design Thinking: Principles, Processes and Applications*, reprint, S. Chand Publishing, 2025.

II B.Tech. I Semester

A9003 – Numerical Methods and Complex Variables

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides mathematical knowledge required to analyze problems encountered in engineering. This course covers numerical methods to evaluate roots of algebraic and transcendental equations, find missing data values by interpolating, and perform numerical differentiation and integration, express periodic and non-periodic functions in terms of sine and cosine, calculus of functions of single complex variable, region of convergence of a power series and theory of residues. This course provides essential techniques for problem-solving skills, with emphasis on both theoretical understanding and practical applications.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9003.1. Apply appropriate Numerical method to approximate the roots of an equation and interpolate to estimate function values at given intermediate points.

A9003.2. Compute an approximate value of a definite integral and obtain numerical solutions for first-order ordinary differential equations.

A9003.3. Construct periodic functions using Fourier series and express non-periodic functions using Fourier transforms in terms of sine and cosine.

A9003.4. Apply Cauchy-Riemann equations to test analyticity and construct harmonic functions using the Milne-Thomson method.

A9003.5. Evaluate integrals along a contour and express complex functions in power series.

Course Syllabus

Unit-I:

Solution of Algebraic and Transcendental Equations: Bisection method, Regula-falsi method, and Newton-Raphson method. Finite Differences: Forward differences, backward differences, symbolic relations and separation of symbols, Interpolation using Newton's forward and backward difference formulae and Lagrange's method of interpolation.

Unit-II:

Numerical Integration: Trapezoidal rule, Simpson's $(1/3)^{rd}$ rule and Simpson's $(3/8)^{th}$ rule.

Numerical solution of first order ODE: Taylor Series, Picard's method, Euler and modified Euler's methods and Runge-Kutta method of fourth order.

Unit-III:

Fourier Series & Fourier Transforms: Fourier series, Dirichlet's Conditions, Half-range Fourier series. Fourier Transforms: Fourier Integral Theorem (Only statements), Fourier Sine and Cosine transforms (Elementary illustrations).

Unit-IV:

Complex Differentiation: Limit, Continuity, differentiability, analyticity and properties, Cauchy-Riemann equations (without proof) in Cartesian and polar coordinates, harmonic and conjugate harmonic functions, Milne-Thomson method to construct analytic function.

Unit-V:

Complex Integration: Line integral in complex plane, Cauchy's integral theorem and Cauchy's integral formula. Complex power series: Taylor's series and Laurent's series. Zeros, singular points and classification of isolated singular points, Residue, Cauchy Residue Theorem.

Books and Materials

Text Books:

1. Grewal, B. S. *Higher Engineering Mathematics*, 43rd ed., Khanna Publications, 2015.
2. Sastry, S.S *Introductory methods of numerical analysis*, 4th ed., Printice Hall India, 2005.

Reference Books:

1. Jain, M.K., Iyengar, S.R.K and Jain, R.K.*Numerical methods for Scientific and Engineering Computations*, 8th ed., New Age International publishers, 2007.
2. Churchill, R.V. and Brown, J.W.*Complex Variables and Applications* , 8th ed., McGraw Hill Education (India) Pvt Ltd, 2009.
3. Kreyszig, E. *Advanced Engineering Mathematics*, 9th ed., John Wiley & Sons, 2006.
4. Kendall E. Atkinson *An introduction to Numerical Analysis* , 2nd ed., John Wiley & Sons, 2008.

A9404 – Probability and Random Processes

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This is the fundamental course in signal processing and communication engineering. This course provides a foundation in the theory and applications of random signals and an understanding of the mathematical techniques relating to random processes in the areas of signal processing and communications. This course also focuses on the application of statistical techniques to the study of random noise concepts. This course forms the basis for the study of advanced courses like Analog and Digital Communications, Radar Communications, Cellular and Mobile Communications, Digital image processing, Speech processing, Machine Learning and Deep learning.

Course Pre/Co-requisites

The course has no specific pre-requisite and co-requisite

Relevant Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure
SDG 13: Climate Action

Course Outcomes

After the completion of the course, the student will be able to:

A9404.1. Apply probability concepts of random variables to determine their distribution and density functions in communication systems.

A9404.2. Apply operations on random variables to solve problems in signal analysis and communication.

A9404.3. Examine the statistical characteristics of random processes relevant to signal modeling.

A9404.4. Analyze the characteristics of noise in communication systems using models of random processes.

A9404.5. Analyze the response of Linear Time-Invariant (LTI) systems to random signal inputs.

Course Syllabus

Unit-I:

Probability and Random Variables: Probability definitions, Joint and Conditional probability, Baye's theorem, Independent events, Random variable concept, Distribution and Density functions-properties, Example random variables: Gaussian, Uniform, Exponential, Binomial, Poisons, Rayleigh. Operations on one random variable: Expectation, Moments, Characteristic functions, Moment Generating Function, Transformation of a random variable.

Unit-II:

Multiple Random Variables: Joint Distribution and Density Functions, Properties, Conditional Distribution and Density Functions, Distribution and Density of a Sum of random variables, Central Limit Theorem, Operations on Multiple Random Variables: Expected Value of a function Random Variables, Joint Moments, Joint Characteristic Functions, Jointly Gaussian Random Variables.

Unit-III:

Random Process - Temporal Characteristics: The Random Process Concept, Classification of Processes, Distribution and Density Functions, Statistical Independence, Stationarity, Time Averages and Ergodicity, Auto-correlation Functions and Its Properties, Cross-Correlation Functions and Its Properties, Covariance Functions.

Unit-IV:

Random Process-Spectral Characteristics: Power Density Spectrum and Its Properties, Relationship Between PSD and ACF, Cross-PSD and its Properties, Relationship Between Cross-PSD And Cross-Correlation Function, Some Noise Definitions, White and Colored Noise, Noise Bandwidth, Properties of Band-Limited Processes.

Unit-V:

Random Signal Response of Linear Systems: System Response-Convolution, Mean and Mean Squared Value of System Response, Autocorrelation Function of response, Cross Correlation Functions of Input and Output, Spectral Characteristics of System Response, Modelling of Resistive Noise Source, Effective Input Noise Temperature, Spot Noise Figures.

Books and Materials

Text Books:

1. Peebles, Peyton Z. *Probability, Random Variables and Random Signal Principles.* 4th ed., Tata McGraw Hill, 2009.

Reference Books:

1. Papoulis, Athanasios, and S. Unnikrishna Pillai. *Probability, Random Variables and Stochastic Processes.* 4th ed., Tata McGraw Hill, 2002.
2. Kay, Steven. *Intuitive Probability and Random Processes Using MATLAB.* Springer US, 2006.

A9405 – Electronic Circuit Analysis

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides an in-depth understanding of the design and analysis of multistage amplifiers, high-frequency transistor models, feedback amplifiers, oscillators, and power amplifiers. Emphasis is placed on analyzing frequency response, signal distortion, coupling techniques, and high-frequency effects using advanced transistor models. The course also explores the principles of feedback and its influence on amplifier performance. It covers the design and functioning of various oscillator types and introduces different classes of power amplifiers, including efficiency considerations and distortion analysis. This course lays a solid foundation for designing analog subsystems in communication, control, and instrumentation applications.

Course Pre/Co-requisites

A9403 – Electronic Devices and Circuits

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9405.1. Apply small signal models to analyse multistage amplifiers in electronic circuits.

A9405.2. Examine the high-frequency response of amplifiers using the hybrid- π model of a transistor.

A9405.3. Analyze the effect of feedback on the performance of amplifiers in electronic circuits.

A9405.4. Design oscillator circuits for a given frequency using Bharkausen ctiteria.

A9405.5. Compare the performance of power amplifiers based on efficiency, distortion, and output power.

Course Syllabus

Unit-I:

Multistage Amplifiers: Classification of amplifiers, distortion in amplifiers, coupling schemes: RC, transformer, direct coupling, frequency response of multistage amplifiers, transistor configuration choice in cascade amplifiers, cascade and cascode amplifiers, Darlington pair amplifier.

Unit-II:

High-Frequency Transistor Model: Hybrid-π model, Hybrid-π parameters: conductances and capacitances, CE short-circuit current gain, gain with resistive load and gain-bandwidth product.

Unit-III:

Feedback Amplifiers: Concept and need for feedback in amplifiers, characteristics of negative feedback, types and classification of feedback amplifiers-voltage series, voltage shunt, current series and current shunt configurations (qualitative analysis).

Unit-IV:

Oscillators: Barkhausen Criterion for oscillations, LC Oscillators: Generalized analysis, Hartley oscillator, Colpitts oscillator, RC Oscillators: RC phase shift oscillator and Wien bridge oscillator, Crystal oscillator-working principle and applications.

Unit-V:

Power Amplifiers: Classification, Series-fed Class A amplifier, Transformer-coupled Class A amplifier, Class B amplifier: Push-pull, Complementary symmetry, Efficiency calculations and Crossover distortion.

Books and Materials

Text Books:

1. Millman, Jacob, Christos C. Halkias, and Chetan D. Parikh. Integrated Electronics: Analog and Digital Circuits and Systems. 2nd ed., Tata McGraw Hill Education Private Limited, 2011.
2. Sedra, Adel S., and Kenneth C. Smith. Microelectronic Circuits. 6th ed., Oxford University Press, 2010.

Reference Books:

1. Boylestad, Robert L., and Louis Nashelsky. Electronic Devices and Circuit Theory. 9th ed., Pearson/Prentice Hall, 2006.
2. Millman, Jacob, and Arvin Grabel. Microelectronics. 2nd ed., Tata McGraw Hill, 2003.

A9406 – Signals and Systems

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course offers a comprehensive introduction to continuous-time signals and systems, covering classification, representation, and analysis in both time and frequency domains. Students learn to apply convolution, Fourier, and Laplace Transforms to analyze system behavior. The course lays a strong foundation for advanced topics in Communication Systems and Signal Processing, making it essential for Electronics and Communication Engineering students.

Course Pre/Co-requisites

A9001 – Matrices and Calculus

A9002 – Ordinary Differential Equations and Vector Calculus

Relevant Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being

SDG 7: Affordable and Clean Energy

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9406.1. Analyze Continuous-Time signals based on their properties and transformations.

A9406.2. Analyze Continuous-Time systems and their responses using convolution.

A9406.3. Evaluate the spectral characteristics of continuous time periodic signals using Fourier series analysis.

A9406.4. Analyze the spectral characteristics of signals and systems using Fourier Transform.

A9406.5. Evaluate the performance and stability of LTI systems using Laplace Transform and ROC analysis.

Course Syllabus

Unit-I:

Continuous Time(CT) Signal Analysis: Introduction to Continuous Time (CT) signals, elementary Signals-Unit Step, Impulse, ramp signals, real exponential signals, sinusoidal signals, Operations on independent variable, Operations on dependent variable, singularity functions, energy and power signals, periodic and aperiodic signals, even and odd symmetry, Causal and non-causal signals.

Unit-II:

Signal Transmission through Linear Systems: Continuous time Systems Classification: Linear systems and Non-linear systems, time varying and time invariant systems, systems with and without memory, causal and Non causal systems, stable and unstable systems, Continuous Convolution: Analysis of LTI Systems, Impulse response of LTI System, graphical interpretation of convolution, Properties of convolution, step response of LTI System.

Unit-III:

Fourier Series: Trigonometric Fourier Series (TFS) and Exponential Fourier Series (EFS), the relationship

between Trigonometric Fourier Series and Exponential Fourier Series, Convergence of Fourier series, Symmetry conditions, Fourier series properties.

Unit-IV:

Fourier Transforms: Fourier Transform (FT), Fourier transform of standard signals, Fourier transforms involving impulse function, Fourier transform of periodic signals, Properties of Fourier transforms, Filter characteristics of LTI system, Distortion less transmission, Sampling: Sampling of continuous-time signals, Sampling theorem, Reconstruction of signal from its samples, the effect of under sampling- Aliasing.

Unit-V:

Laplace Transforms: The Laplace Transform (LT), The Region of convergence (ROC) for Laplace transforms, Properties of Laplace Transforms, some Laplace transform pairs, Inverse Laplace Transforms, Partial fraction method, The Transfer Function, Analysis and characterization of LTI system using Laplace Transform, Causality and Stability of a System.

Books and Materials

Text Books:

1. Oppenheim, Alan V., and Alan S. Willsky. *Signals and Systems.* 2nd ed., Prentice Hall of India, 2009.
2. Haykin, Simon, and Barry Van Veen. *Signals and Systems.* 2nd ed., John Wiley & Sons (Asia) Pte Ltd, 2007.

Reference Books:

1. Kumar, Anand. *Signals and Systems.* 3rd ed., PHI Learning Pvt. Ltd., 2019
2. Lathi, B. P. *Signals, Systems and Communications.* BS Publications, 2001.

A9407 – Linear Control Systems

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course deals the modeling of linear systems and using feedback to improve their performance. The progression of topics in the course includes differences between open loop and closed-loop control systems, use of feedback to improve tracking, mitigate the effects of unwanted signals (disturbances), and render a system less sensitive to changes in system parameters.PID controllers and stability testing with Root Locus and the Nyquist criterion. It also focuses on state-space design to demonstrate the applicability of linear algebra methods to characterize system response and lead to the use of state feedback for system stabilization or control.

Course Pre/Co-requisites

A9002 – Ordinary Differential Equations and Vector Calculus

Relevant Sustainable Development Goals (SDGs)

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9407.1. Analyze and simplify open-loop and closed-loop transfer functions using block diagram reduction methods, signal flow graphs, and Mason's gain formula.

A9407.2. Apply the principles of time response analysis in control systems to evaluate systems with first and second-order dynamics.

A9407.3. Analyze control system stability using Routh's criterion and evaluate the effects of adding poles and zeros to G(s)H(s) through root locus analysis.

A9407.4. Analyze frequency domain specifications using Bode diagrams, and assess system stability through phase margin, gain margin, Polar plots, and Nyquist plots.

A9407.5. Apply compensation techniques and PID controllers to improve control system performance, and interpret state space representations.

Course Syllabus

Unit-I:

Basics of Control Systems: Introduction to control problem, Open loop and closed loop control systems and differences, effects of feedback. Mathematical modelling of control systems- Differential equations and transfer function of electrical systems, Block diagram representations and reduction rules, Signal flow graph representation, reduction using Mason's gain formula.

Unit-II:

Time Response Analysis: Standard test signals, characteristic equation of feedback control system, time response of first order system and second order system, concept of damping ratio, natural frequency, Classification based on damping ratio, transient response of second order under damped system, time domain specifications, steady state response, steady state errors and static error constants(Kp,Kv,Ka).

Unit-III:

Routh's Stability and Root Locus Technique: The concept of stability, Routh's stability criterion, qualitative stability and conditional stability, limitations of Routh's stability. The root locus concept, construction of root loci, effects of adding poles and zeros to G(s)H(s)on the root loci.

Unit-IV:

Frequency Response Analysis: Introduction, frequency domain specifications, Polar plots, construction of Bode diagrams, phase margin and gain margin, stability analysis from Bodeplots and polar plots. Nyquist stability analysis- principle of argument, Nyquist plots, Nyquist stability analysis.

Unit-V:

Controllers and State space analysis: Compensation techniques, Lag, Lead, and Lead Lag Compensators, P, PI & PID Controllers. Concepts of state, state variables and state model, various state models representations- CCF, OCF, DCF, JCF, state transition matrix and its properties, solving the time invariant state equations, concepts of controllability and observe ability.

Books and Materials

Text Books:

1. Nagrath, I. J., and M. Gopal. *Control Systems Engineering.* 5th ed., New Age International (P) Ltd., 2011.
2. Kuo, Benjamin C. *Automatic Control Systems.* 8th ed., John Wiley and Sons, 2003.

Reference Books:

1. Ogata, Katsuhiko. *Modern Control Engineering.* 8th ed., Prentice Hall of India Pvt. Ltd., 2008.
2. Sinha, N. K. *Control Systems.* 3rd ed., New Age International Limited Publishers, 2008

A9408 – Electronic Devices and Circuit Analysis Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course provides hands-on experience in the analysis and design of analog electronic circuits using both hardware and simulation tools. Students will explore the behavior of semiconductor devices such as diodes, BJTs, JFETs, and MOSFETs under various configurations. The course emphasizes practical skills in designing amplifiers, rectifiers, oscillators, and power amplifiers, as well as simulating circuits to evaluate performance parameters such as gain, distortion, ripple factor, and frequency response. By integrating theoretical knowledge with experimental validation, this course aims to strengthen circuit-level understanding and prepare students for real-world analog system design challenges.

Course Pre/Co-requisites

A9403 – Electronics Devices and Circuits.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 9: Industry, Innovation, and Infrastructure
SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9408.1. Perform and analyze the characteristics of diodes and transistors under various biasing conditions.

A9408.2. Design and implement amplifiers and oscillator circuits for the given specifications.

A9408.3. Build electronic circuits making use of diodes and transistors and verify the operation practically.

A9408.4. Analyze the effect of feedback and cascading in amplifiers in terms of gain and bandwidth.

A9408.5. Construct and analyze power amplifier circuits to measure efficiency, and identify distortion effects.

Course Syllabus

A. Hardware-Based Experiments:

1. Study the I–V characteristics of a PN junction diode in forward and reverse bias to determine cut-in voltage and dynamic resistance.
2. Design and analyze full-wave rectifiers (center-tapped and bridge) with and without capacitor filters to evaluate ripple factor and output voltage.
3. Plot the input and output characteristics of a BJT in common base configuration to determine input/output resistance and current gain.
4. Design and test voltage divider bias circuits to establish a stable operating point for a BJT amplifier and study DC load line behavior.
5. Design and analyze a two-stage RC coupled amplifier to demonstrate gain enhancement and study coupling capacitance effects.
6. Design Hartley and Colpitts oscillators for a specified frequency and observe their output waveforms.
7. Design a class A power amplifier, observe input/output waveforms, and calculate efficiency.

B. Software-Based Simulation Experiments (7):

1. Simulate a common emitter amplifier with and without emitter bypass capacitor to analyze the effect on voltage gain and signal amplification.
2. Simulate the output and transfer characteristics of a JFET to determine parameters such as pinch-off voltage, drain resistance, and transconductance.
3. Simulate the output and transfer characteristics of a MOSFET.
4. Simulate voltage series feedback amplifier and compare it's frequency responses with and without feedback.
5. Simulate Darlington pair amplifier to demonstrate gain enhancement and study coupling capacitance effects.
6. Simulate RC phase shift and Wien bridge oscillators for a specified frequency and observe their output waveforms.
7. Simulate a complementary symmetry push-pull amplifier and verify elimination of crossover distortion.

Laboratory Equipment/Software/Tools Required:

1. Cathode Ray Oscilloscope
2. Function Generator
3. Regulated Power Supply
4. Multimeters
5. Discrete Components
6. Breadboard
7. Computers installed with operating system
8. Multisim Software

Books and Materials

Text Books:

1. Millman, Jacob, Christos C. Halkias, and Chetan D. Parikh. *Integrated Electronics: Analog and Digital Circuits and Systems.* 2nd ed., Tata McGraw Hill Education Private Limited, 2011.
2. Sedra, Adel S., and Kenneth C. Smith. *Microelectronic Circuits.* 6th ed., Oxford University Press, 2010.

Reference Books:

1. Boylestad, Robert L., and Louis Nashelsky. *Electronic Devices and Circuit Theory.* 9th ed., Pearson/Prentice Hall, 2006.
2. Millman, Jacob, and Arvin Grabel. *Microelectronics.* 2nd ed., Tata McGraw Hill, 2003.

A9409 – System Modelling and Simulation Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course provides fundamental knowledge and practical skills in Signals and Systems, utilizing the MATLAB tool for numerical computations and visualization. It covers the analysis of continuous time signals and systems in both the time and frequency domains. Students will explore sampling and reconstruction, which are essential backgrounds for understanding signal processing and communications. The course is structured as a practical learning experience, offering hands-on training with the MATLAB tool.

Course Pre/Co-requisites

A9001 – Matrices and Calculus

A9002 – Ordinary Differential Equations and Vector Calculus.

Relevant Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being

SDG 7: Affordable and Clean Energy

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9409.1. Interpret the concepts of continuous time signals and systems using MATLAB.

A9409.2. Analyze the behavior of continuous time LTI systems using transform analysis and convolution.

A9409.3. Evaluate the spectral characteristics of continuous time-periodic and aperiodic signals using transformation techniques.

A9409.4. Apply the concepts of signals to determine their energy, power, PSD using Autocorrelation and cross correlation functions.

A9409.5. Analyze and evaluate the stability, controllability, and frequency response characteristics of linear control systems using classical techniques.

Course Syllabus

Signals and Systems (Any 6 Experiments)

1. Generation of Standard Signals and Sequences such as Unit Impulse, Unit Step, Ramp, Signum, Square, Triangular pulse, Sinusoidal, Sinc, and Real exponential signals.
2. Perform the operations on the Independent variable of continuous time signals such as Scaling, Shifting, and Folding.
3. Perform the operations on the dependent variable of continuous time signals such as Addition, Subtraction, Multiplication and amplitude scaling.
4. Find the energy, power, even and odd components of a continuous time signal.
5. Verification of linearity and time invariance properties of a given continuous time system.
6. Find the convolution between two continuous time signals.

7. Find the Impulse response of a given continuous LTI system and plot magnitude and phase response.
8. Compute Trigonometric Fourier series and Exponential Fourier series coefficients of a continuous periodic signal.
9. Observing Gibbs Phenomenon in Fourier Series reconstruction.
10. Computation of the Fourier Transform and Laplace of standard signals and plotting its magnitude and phase spectrum.

Probability and Random Processes (Any 5 Experiments)

1. Generation of distribution/ density functions of various random variables like Uniform, Rayleigh, Gaussian, Poisson and Bernoulli using MATLAB.
2. Generation of Random Numbers from Normal Distribution with Specific Mean and Variance using MATLAB
3. Plot the cross correlation of the following signal:

$$x(n) = \sin(2\pi f_1 t), \quad f_1 = 1\,\text{Hz}$$

$$y(n) = x(n) + w(n)$$

   where $w(n)$ is a zero mean, unit variance of Gaussian random process using MATLAB.
4. Estimation of Power Spectral Density using autocorrelation function of a given random signal using MATLAB.
5. Verifying Sampling theorem for different sampling rates, Sampling types and Duty Cycles and for plotting the sampled and reconstructed Signals.
6. Extraction of Periodic signal masked by noise using correlation using MATLAB
7. Removal of Noise by Auto Correlation / Cross Correlation in a Given Signal Corrupted by Noise.

Linear Control Systems (Any 3 Experiments)

1. Implementation of a PID Controller
2. Verification of Controllability and Observability of a given system.
3. Verify the stability of a given system using R-H Criterion
4. Calculate the gain margin, phase margin, gain crossover frequency, phase crossover frequency for the given system and draw the bode plot.
5. Calculate the gain margin and phase margin for the given system and draw the polar plot.

Laboratory Equipment/Software/Tools Required:

1. Simulation Software (MATLAB, Scilab, Octave etc.)

Books and Materials

Text Books:

1. Oppenheim, Alan V., and Alan S. Willsky. *Signals and Systems.* 2nd ed., Prentice Hall of India, 2009.
2. Peebles, Peyton Z. *Probability, Random Variables and Random Signal Principles.* 4th ed., Tata McGraw Hill, 2009.
3. Nagrath, I. J., and M. Gopal. *Control Systems Engineering.* 5th ed., New Age International (P) Ltd., 2011.

Reference Books:

1. Kumar, Anand. *Signals and Systems.* 3rd ed., PHI Learning Pvt. Ltd., 2019
2. Lathi, B. P. *Signals, Systems and Communications.* BS Publications, 2001.
3. Papoulis, Athanasios, and S. Unnikrishna Pillai. *Probability, Random Variables and Stochastic Processes.* 4th ed., Tata McGraw Hill, 2002.
4. Ogata, Katsuhiko. *Modern Control Engineering.* 8th ed., Prentice Hall of India Pvt. Ltd., 2008.

A9410 – Applied Python Programming Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This laboratory course introduces Python programming with a strong foundation in structured coding practices and data manipulation. Students engage with datasets to develop skills in analysis, visualization, and mathematical modelling. Through libraries like NumPy, Pandas, Matplotlib, NetworkX, and SciPy, students solve problems relevant to systems involving signal handling, data communication, algorithm design, and hardware-level computations. The course builds a computational thinking approach useful for applications spanning simulation, data-driven design, and control-based systems.

Course Pre/Co-requisites

A9501 – Programming for Problem Solving

A9502 - Programming for Problem Solving Laboratory.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 8: Decent Work and Economic Growth

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

SDG 17: Partnerships for the Goals

Course Outcomes

After the completion of the course, the student will be able to:

A9410.1. Apply Python fundamentals including loops, lists, and functions to solve structured problems.

A9410.2. Develop Python programs using NumPy and Pandas for effective data manipulation and visualization.

A9410.3. Analyze and interpret datasets using Matplotlib, SciPy, and statistical techniques such as t-tests and Fourier transforms.

A9410.4. Demonstrate proficiency in using Python for network analysis and linear algebra operations through NetworkX and NumPy.

A9410.5. Integrate multiple Python libraries to build and visualize data-driven solutions involving complex structures and multidimensional arrays.

Course Syllabus

List of Experiments:

1. Basic Python Programs on Loops and Lists
   a. Write a python program to add all odd numbers between 1 and n.
   b. Write a Python program to print the following pattern:
      1
      2 3
      4 5 6

7 8 9 10
11 12 13 14 15

c. Given a List, extract all elements whose frequency is greater than K.
Input: test_list = [4, 6, 4, 3, 3, 4, 3, 4, 3, 8], K = 3
Output: [4, 3]

d. Given two Python lists, iterate over both lists simultaneously such that list1 should display items in original order and list2 in reverse order. Once the smaller list exhausts, the other list elements should be printed alone.
Input: list1 = [10, 20, 30, 40]; list2 = [1, 10, 100, 200, 300, 400]
Output: 10 400 20 300 30 200 40 100 10 1

2. Python Programs using User Defined Functions

a. Write a function to read data from a file and display it on the screen

b. Write a python program to find factorial of a given number using Recursive function

c. Write a Python program to check whether a given Boolean function is a palindrome or not.

d. Write a function collatz(x) which does the following: if x is odd, $x = 3x+1$; if x is even, then $x = x/2$. Return the number of steps it takes for $x = 1$.

e. Write a Python program using a user-defined function to generate the Fibonacci series up to n terms.

3. Python Programs Using Lists and NumPy

a. Display the indexes and values of the following list using the range() function, Example: a = ['Mary', 'had', 'a', 'little', 'lamb'] Output: 0 Mary 1 had 2 a 3 little 4 lamb

b. Write a Python program to compute the sum of all the elements of each tuple stored inside a list of tuples. Input: [(1, 2), (2, 3), (3, 4)] Output: Sum of all the elements of each tuple: [3, 5, 7]

c. A list baseball has already been defined in the below, representing the height of some baseball players in centimetres. Prepare this as a numpy array. Baseball= [180,215,210,210,188,176,209,200]

d. Create a numpy array from baseball list defined in $Q \neq 1$. Name this new array np_height_in.
(i) Print np_height_in.
(ii) Multiply np_height_in with 0.0254 to convert all height measurements from inches to metres. Store the new values in a new array, np_height_m.
(iii) Print out np_height_m and check if the output makes sense.

4. The package scipy and pyplot

a. Write a Python program using SciPy to check whether two sets of data have the same mean value (perform a t-test).

b. Write a Python program to read data from a file and plot it using Matplotlib Pyplot.

c. Write a Python program to fit a polynomial function through a set of data points using the polyfit function and plot the fitted curve.

d. Write a Python program to plot a histogram of a given dataset using Pyplot.

e. Write a Python program to compute and plot the Fourier Transform of a signal using SciPy.

f. Write a Python program to solve an ordinary differential equation (ODE) numerically using scipy and plot the solution.

5. Python Programs on 2D Array Operations Using NumPy
The dataset baseball is provided as a list of lists, where each inner list contains the height (in cm) and

weight (in kg) of a baseball player. For example: baseball = [[180, 78.4], [215, 102.7], [210, 98.5], [188, 75.2]] Perform the following tasks:

a. Convert the baseball list into a 2D NumPy array using np.array() and store it in a variable named np_baseball.
b. Print the data type of np_baseball.
c. Print the shape (number of rows and columns) of np_baseball using the.shape attribute

6. Python Programs on Data Analysis Using NumPy
You've contacted FIFA for some data and they handed you three lists. The lists are the following:
height = np.round(np.random.normal(1.75, 0.20, 1000), 2)
weight = np.round(np.random.normal(60.32, 15, 1000), 2)
age = np.round(np.random.normal(30, 10, 1000), 0)
let's stack it altogether
np_players = np.column_stack((height, weight, age))
Each element in the lists corresponds to a player. The first list, height, representing each player's height in metres. The second list, weight, represents each player's weight in kilograms. The third list, age, representing each player's age in years.

a. Create a numpy array np_height that is equal to the first column of np_players.
b. Print out the mean of np_height .
c. Print out the median of np_height.

7. Python Programs Using Pandas

a. Write a Program using Pandas to Combine Datasets: Merge.
b. Write a Program using Pandas to Combine Datasets: Join.
c. Write a Program using Pandas on Pivot Tables
d. Write Program using Pandas for performing Vectorised String Operations.

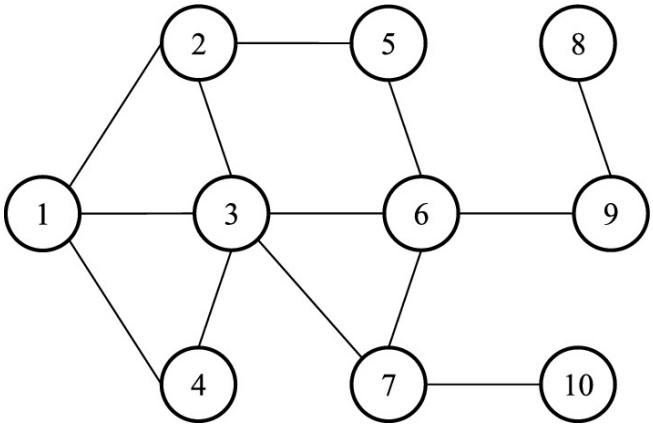
8. Python Programs on Data Analysis and Visualization Using Pandas and Matplotlib
The dataset contains information about MBA applicants across 22 different industries. Perform the following tasks:

a. Read the data file into a pandas Data Frame. Use the head() method to verify that the data has been loaded correctly.(Hint: Add the %matplotlib inline statement at the top of the code block and import pandas and matplotlib.pyplot.)
b. Create a scatter plot of Average Age vs. Average GMAT Score.
c. Create two histograms to show how the Average GMAT and Average Previous Work Experience are distributed across industries.
d. For the first histogram (GMAT distribution), plot it on a x0, choose an appropriate bin size to display detailed information, and label the x-axis properly.
e. Add a vertical dashed line representing the average value and include an annotation for it.
f. Create the second histogram for Work Experience following the same approach.
g. Create a 1×3 figure with a shared y-axis and three subplots. Set figsize = (10, 10) and add an appropriate title to the figure.

9. Python Programs Using NetworkX

a. Create the following undirected using networkx

b. Compute degree of each node in the graph
c. Compute the histogram of degrees. Plot it using matplotlib
d. Compute the average of the nodes using python code.
e. Draw the above graph using matplotlib



10. Python Programs on Linear Algebra Operations Using NumPy
Use the python linear algebra package to solve the below problems.
    a. Create a random matrix of size 5x5, containing only integers. Find the eigenvalues and eigenvectors using numpy.
    b. Is this matrix invertible? Compute the determinant
    c. If the matrix is invertible, find the invertible matrix
    d. Solve the following system of linear equations
        i. $x + 2y + 2z = 5$
        ii. $3x - 2y + z = -6$
        iii. $2x + y - z = -1$

Laboratory Equipment/Software/Tools Required:

1. Computer Systems (PCs) installed with Ubuntu & Windows OS
2. Python , Jupyter notebook , Anaconda (Open Source/ Freeware)

Books and Materials

Text Books:

1. Thareja, Reema. *Python Programming: Using Problem-Solving Approach.* Oxford University Press, 2017.
2. Nelli, Fabio. *Python Data Analytics with Pandas, NumPy, and Matplotlib.* 2nd ed., Apress, 2018.

Reference Books:

1. VanderPlas, Jake. *Python Data Science Handbook.* 1st ed., O'Reilly Media, 2017.
2. Blair, Steve. *Python Data Science.* 1st ed., O'Reilly Media, 2019.

A9006 – Computational Mathematics Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course provides hands-on experience in solving mathematical problems using computational tools. This course covers numerical methods and implementation using MATLAB or Python. The course helps to develop skills in algorithm development, data visualization, and scientific computing. In addition, the computational methods for real- world mathematical modeling can be applied.

Course Pre/Co-requisites

A9001 - Matrices and Calculus

A9002 - Ordinary Differential Equations and Vector Calculus

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9006.1. Develop the code to find the Eigen values and Eigen Vectors using Python/MATLAB

A9006.2. Develop the code to find solution of Algebraic and Transcendental using Python/MATLAB

A9006.3. Develop the code to find solution of Linear system of equations using Python/MATLAB

A9006.4. Write the code to solve problems of First-Order linear differential equations with constant coefficients

A9006.5. Write the code to solve problems of Higher order linear differential equations with constant coefficients

Course Syllabus

List of Experiments:

Visualize all solutions graphically using programs.

1. Eigen values and Eigen Vectors
   a. Finding real and complex Eigen values.
   b. Finding Eigen vectors.
2. Solution of Algebraic and Transcendental Equations - Bisection method, Newton Raphson Method
   a. Root of a given equation using Bisection method.
   b. Root of a given equation using Newton Raphson Method.
3. Linear system of equations - Jacobi's iteration method and Gauss-Seidal iteration method
   a. Solution of given system of linear equations using Jacobi's method.
   b. Solution of given system of linear equations using Gauss-Seidal method.

4. First-Order ODEs - Exact and non-exact equations, Applications: exponential growth/decay, Newton's law of cooling
   a. Solving exact and non-exact equations.
   b. Solving exponential growth/decay and Newton's law of cooling problems.
5. Higher order linear differential equations with constant coefficients
   a. Solving homogeneous ODEs.
   b. Solving non-homogeneous ODEs.

Books and Materials

Text Books:

1. Rajkumar Basal, Ashok Kumar Geo, and Manoj Kumar Sharma. *MATLAB and Its Applications in Engineering*. Pearson.
2. Kenneth A. Lambert. *The Fundamentals of Python: First Programs*. Cengage Learning, 2011.
3. Allen B. Downey. *Think Python*. 1st ed., O'Reilly Media.

Reference Books:

1. William Mitchell, Povel Solin, Martin Novak, et al. *Introduction to Python Programming*. NCLab Public Computing, 2012.
2. Jacob Fredslund. *Introduction to Python Programming*. 2007.
3. John C. Lusth. *An Introduction to Python*. University of Alabama, 2011.
4. Dave Kuhlman. *Introduction to Python*. 2008.

A9411 – Linux and Shell Scripting

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This skill based course offers practical experience in Linux and shell scripting, focusing on automation, process management, and inter-process communication using C. Students will explore essential Linux commands, develop shell scripts to streamline tasks, and build client-server applications using sockets. This course also introduces basic TCL scripting for automating programming tasks. Through guided experiments, students gain foundational skills essential for systems programming, network communication, and automation in real-world Linux and embedded system environments.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9411.1. Use essential Linux commands to manage files, directories, and system-level operations effectively.

A9411.2. Create and execute shell scripts to automate routine administrative and programming tasks.

A9411.3. Develop C programs for process management and inter-process communication using Linux system calls.

A9411.4. Design and implement client-server applications using socket programming and networking protocols in C.

A9411.5. Develop and apply TCL scripts for automation tasks in programming and design tool environments.

Course Syllabus

List of Experiments:

1. Practice on essential Linux commands: cp, mv, mkdir, ps, who, du, df, find, etc.
2. Practice on text processing commands: cat, grep, cut, awk, sort, uniq, diff, tr.
3. a. Shell script to display lines between given line numbers
   b. Shell script to delete lines containing a specific word
4. a. Shell script to list files with read, write, execute permissions
   b. Check if arguments are files or directories
5. a. awk script to count lines without vowels
   b. Count characters, words, and lines in a file
6. a. C program to copy a file using system calls

b. Implement cat, mv, ls, ls -l, ls -a using system calls

7. a. Create parent and child processes
   b. Create zombie and orphan processes
8. a. Handle process suspension and resumption using signals
   b. Signal handlers for SIGINT, SIGQUIT, SIGFPE
9. a. IPC with named pipes (FIFO)
   b. Parent-child communication using pipes
10. a. Client-server communication using Unix domain sockets
    b. Internet domain sockets
11. a. TCL script for factorial using loops
    b. Create and manipulate a list
12. TCL script to read configuration files and extract parameters

Laboratory Equipment/Software/Tools Required:

1. Computers installed with Linux operating system and C Compiler (GCC)
2. Networking Equipment (for client-server experiments)

Books and Materials

Text Books:

1. Matthew, Neil, and Richard Stones. *Beginning Linux Programming.* 4th ed., Wrox/Wiley India, 2008.
2. Love, Robert. *Linux System Programming.* O'Reilly Media, 2007.
3. Tripathi, Suman Lata, Abhishek Kumar, and Jyotirmoy Pathak. *Programming and GUI Fundamentals: TCL-TK for Electronic Design Automation (EDA).* John Wiley & Sons, 2023.

Reference Books:

1. Chan, Terrence. *Unix System Programming Using C++.* Prentice Hall PTR, 1997.
2. Das, Sumitabha. *Unix Concepts and Applications.* 4th ed., Tata McGraw-Hill, 2006.
3. Stevens, W. Richard. *Advanced Programming in the UNIX Environment.* 2nd ed., Pearson Education, 2005.
4. Stevens, W. Richard. *Unix Network Programming.* PHI Learning, 1990.

A9023 - Technology Entrepreneurship

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	0	45	45	1	40	60	100

Course Description

Course Overview

This course enables students to transform refined product designs into viable entrepreneurial ventures or patentable innovations. Building on skills from previous courses in design thinking and product development, students will explore opportunity identification, intellectual property protection, market research, sustainable business models, funding strategies, and go-to-market planning. Emphasis is placed on aligning innovations with community needs while preparing for startup creation, patent filing, or both.

Course Pre/Co-requisites

A9022 - Product Design and Development

textbfRelevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 8: Decent Work and Economic Growth

SDG 9: Industry, Innovation, and Infrastructure

SDG 17: Partnerships for the Goals

Course Outcomes

After the completion of the course, the student will be able to:

A9023.1. Identify and analyze market opportunities for community-driven technological innovations.

A9023.2. Apply intellectual property strategies for protecting product designs and innovations.

A9023.3. Develop sustainable and scalable business models for product commercialization.

A9023.4. Formulate funding, financial, and go-to-market strategies for product launch.

A9023.5. Prepare and deliver investor-ready pitches or patent documentation to relevant stakeholders.

Course Syllabus

Unit-I:

Entrepreneurial Mindset and Opportunity Identification: Understanding technology entrepreneurship in the community context. Startup ecosystem and innovation pathways. Market analysis and opportunity mapping for commercialization of Product.

Unit-II:

Intellectual Property and Innovation Protection: Overview of IP: patents, trademarks, copyrights, and trade secrets; patent search, drafting, filing, and grant procedures; leveraging IP for competitive advantage and innovation scaling.

Unit-III:

Market Research and Business Model Development: Defining target markets, customer segments, and value propositions. Competitive analysis and differentiation strategies. Business Model Canvas and Lean Startup principles.

Unit-IV:

Funding, Financial Planning and Sustainability: Study of funding options including grants, angel investors, venture capital, and crowd funding; budgeting, forecasting, and financial planning for startups; and integration of sustainability into long-term business growth strategies.

Unit-V:

Go-to-Market Strategy, Pitching and Documentation: Branding, marketing, and distribution planning; creating persuasive pitches for investors, partners, and stakeholders; preparing necessary documentation; final presentation of patent draft or startup business plan to an expert panel.

Activity Plan

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
1	Unit-I: Entrepreneurial Mindset	Understand technology entrepreneurship & startup ecosystem	Concept briefing + Open forum	Discussion: examples of community-based startups	Reflection note: "Why entrepreneurship matters for communities"	CO1
2	Unit-I: Opportunity Identification	Identify & map opportunities	Hands on session + Case analysis	Opportunity mapping using local problems	Opportunity mapping chart submission	CO1
3	Unit-II: IP Basics	Learn types of IP (patents, trademarks, copyrights)	Concept briefing + Example-driven discussion	Analyze famous patents & trademarks	Short report: "One innovation and its IP protection strategy"	CO2
4	Unit-II: Patent Process	Apply patent search & filing basics	Demo session + Hands-on exercise	Perform a mock patent search online (guided)	Draft simple patent claim for a product	CO2
5	Unit-III: Market Research	Define target market & customer segments	Concept briefing + Team activity	Build customer personas for chosen product idea	Submit customer persona & value proposition canvas	CO3
6	Unit-III: Business Model Development	Apply BMC & Lean Startup	Business modeling – Hands on session	Teams fill out Business Model Canvas	Submit BMC with initial differentiation strategy	CO3
7	Unit-IV: Funding Sources	Understand startup funding landscape	Concept briefing + Case discussion	Funding source comparison (VC, grants, crowdfunding)	Assignment: Funding strategy document for idea	CO4

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
8	Unit-IV: Financial Planning	Apply budgeting & forecasting	Hands on session	Build basic revenue/cost projection table	Submit 1-year financial projection	CO4
9	Unit-IV: Sustainability	Integrate sustainability in startups	Group reflection	Apply sustainability checklist to business model	Submit revised BMC integrating sustainability	CO4
10	Unit-V: Go-to-Market	Learn branding & marketing strategies	Hands on session + Peer feedback	Draft a marketing plan with target channels	Submit draft marketing & distribution strategy	CO4, CO5
11	Unit-V: Pitching Skills	Develop persuasive pitch	Startup pitch drill	Students deliver 3-min practice pitches with feedback	Submit pitch deck draft	CO5
12	Unit-V: Final Showcase	Present final startup plan/patent draft	Showcase + Expert review	Final presentations to panel (faculty/guests)	Final project submission: startup plan or patent draft	CO5

Books and Materials

Text Books:

1. Deependra Sharma. *Entrepreneurship in India* , Routledge, 2023.
2. Dr. S. Glory Swarupa & Ms. Swapna Vanamala. *Innovation, Incubation and Intellectual Property Rights*, 2023.

Reference Books:

1. Neck, Heidi M., Patricia G. Greene, and Candida G. Brush. *Teaching Entrepreneurship: A Practice-Based Approach*, Edward Elgar Publishing, 2014.
2. Drucker, Peter F. *Innovation and Entrepreneurship: Practice and Principles*, reprint, Harper & Row, 1985.

II B.Tech. II Semester

A9014 - Business Economics and Financial Analysis

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces the fundamentals of Business Economics and Financial Analysis, covering business structures, economic concepts, demand and supply analysis, production and cost, market structures, and pricing. It also focuses on accounting principles, preparation of financial statements, ratio analysis, and capital budgeting methods to support effective financial decision-making.

Course Pre/Co-requisites

This course has no specific prerequisite and co-requisite.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure
SDG 17: Partnerships for the Goals

Course Outcomes

After the completion of the course, the student will be able to:

A9014.1. Analyze business and economic concepts to assess their impact on the overall economic environment.

A9014.2. Examine the relationship between demand, supply, and elasticity in understanding market behavior.

A9014.3. Apply production, cost, market structure, and pricing concepts to interpret business operations and competitive strategies.

A9014.4. Apply accounting principles and rules for preparing financial statements.

A9014.5. Analyze financial statements and capital budgeting techniques to evaluate the financial health of a business.

Course Syllabus

Unit-I:

Introduction to Business and Economics: Business-Structure of Business Firm, Types of Business Entities, Limited Liability Companies, Sources of Capital for company – Conventional and Non-Conventional. Economics-Significance of Economics, Micro and Macro Economic Concepts. Business Economics- Nature and Scope, Role of Business Economist. National Income-Concepts and Importance, Inflation and Money Supply. Business Cycle -Features and Phases.

Unit-II:

Demand and Supply Analysis: Demand-Function, Determinants and types. Law of Demand-Assumption and Exceptions. Elasticity of Demand- Types, Measurement and Significance of Elasticity of Demand, Factors affecting Elasticity of Demand. Demand Forecasting- Methods of Demand Forecasting. Supply Analysis-Functions, Determinants and Law of Supply.

Unit-III:

Production, Cost, Market Structures & Pricing: Production Analysis- Factors of Production, Production Function, Production Function with one variable input, two variable inputs, Returns to Scale. Cost analysis: Types of Costs, Short run and Long run Costs Break Even Analysis (simple problems). Market Structure: Nature of Competition, Features of Perfect competition, Monopoly, Oligopoly, Monopolistic Competition. Pricing-Types of Pricing, Product Life Cycle based Pricing,

Unit-IV:

Financial Accounting: Accounting concepts and Conventions, Accounting Equation, Double Entry system of Accounting, Rules for maintaining Books of Accounts, Journal, Posting to Ledger, Preparation of Trial Balance, Elements of Financial Statements, Preparation of Final Accounts (Simple Problems).

Unit-V:

Ratios Analysis and Capital Budgeting: Concept of Ratio Analysis, Importance and Types of Ratios- Liquidity Ratios, Turnover Ratios, Profitability Ratios, Proprietary Ratios, Solvency, Leverage Ratios– Analysis and Interpretation. Capital Budgeting – Capital, Types of capital, Capital Budgeting Methods (Simple Problems).

Books and Materials

Text Books:

1. D. Chaturvedi, S. L. Gupta. *Business Economics Theory and Applications* 4th ed., Interna tional Book House Pvt. Ltd. 2013.
2. Dhanesh K Khatri. *Financial Accounting*, 3rd ed., Tata Mc–Graw Hill, 2011.

Reference Books:

1. Geethika Ghosh, Piyali Gosh, Purba Roy Choudhury. *Managerial Economics*, 2nd ed., Tata Mc Graw Hill Education Pvt. Ltd. 2012.
2. A.R. Aryasri, *Managerial Economics and Financial Analysis*, 9th ed., TMH, India, 2011.
3. Geethika Ghosh, Piyali Gosh, Purba Roy Choudhury. *Managerial Economics*, 2nd ed., Tata Mc Graw Hill Education Pvt. Ltd. 2012.

A9414 – Digital Signal Processing

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces the fundamentals of Digital Signal Processing (DSP), covering discrete-time signals, systems, and their analysis using Fourier and Z-transforms. It emphasizes system properties, convolution, and efficient computation through DFT and FFT. The course explores realization and design of digital filters, including IIR and FIR filters, using standard design techniques. Students will gain practical skills in filter design and frequency domain analysis for applications in communications, audio, and signal processing systems.

Course Pre/Co-requisites

A9406 – Signals and Systems

Relevant Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being
SDG 7: Affordable and Clean Energy
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9414.1. Apply the fundamentals of signals and systems to obtain the response of DT systems.
A9414.2. Analyze Discrete time signals and systems using Discrete Fourier transforms.
A9414.3. Evaluate system properties using Z-transform and implement IIR/FIR filter structures.
A9414.4. Design and implement digital IIR filters for given specifications.
A9414.5. Design and implement digital FIR filters for given specifications.

Course Syllabus

Module-I:

Introduction to Digital Signal Processing: Discrete time signals & systems, linear shift invariant systems, stability and causality; LTI system response: solution of Linear Constant Coefficient Difference Equation (LCCDE), Convolution.

Module-II:

Discrete Fourier Transform: Frequency domain representation and analysis of discrete time signals and systems; Discrete Fourier transforms: frequency domain sampling, DFT as a linear transformation, Relationship of DFT to other transforms, Properties of DFT, linear convolution of sequences using DFT; Fast Fourier transforms (FFT): Radix-2 FFT algorithm, Inverse FFT.

Module-III:

Z-Transform: Z transform of standard signals, The Region of Convergence (ROC) for Z - transform and its properties, Properties of Z -transform, Transfer Function of system, Causality and Stability using Z-transform, Inverse Z- Transform. **Realization of Digital filters:** Realization of IIR filters: Direct form structures,

cascade form structure, Parallel form structure. Realization of FIR filters: Direct form structure, Cascade form structure and linear phase structure.

Module-IV:

Design of IIR Digital Filters: IIR filter design by Approximation of Derivatives, IIR filter design by impulse invariance, IIR filter design by bilinear transformation, Characteristics of commonly used analog filters (Butterworth and Chebyshev), Frequency transformations.

Module-V:

Design of FIR Digital Filters: Symmetric and antisymmetric FIR filters, Frequency response of linear FIR filters, Design of FIR Filters: Fourier Series Method, Windowing techniques. comparison of IIR & FIR filters.

Books and Materials

Text Books:

1. Proakis, John G., and Dimitris G. Manolakis. *Digital Signal Processing: Principles, Algorithms, and Applications.* 4th ed., Pearson Education/PHI, 2007.
2. Singh, Avtar, and S. Srinivasan. *Digital Signal Processing.* Thomson Publications, 2006.

Reference Books:

1. Hayes, Monson H. *Schaum's Outline of Digital Signal Processing.* Tata McGraw-Hill, 2007.
2. Schilling, Robert J., and Sandra L. Harris. *Fundamentals of Digital Signal Processing Using MATLAB.* Thomson Publications, 2007.
3. Manolakis, Dimitris G., and Vinay K. Ingle. *Applied Digital Signal Processing.* Cambridge University Press, 2011.

A9415 – Integrated Circuits and Applications

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course introduces the fundamentals and applications of Integrated Circuits (ICs), focusing on Operational Amplifiers (Op-Amps) and their linear and non-linear configurations. It explores the internal structure and ideal characteristics of Op-Amps, followed by practical circuit applications such as amplifiers, filters, oscillators, and waveform generators. The course further covers active filter design, voltage regulation using ICs, and the operation of IC 555 timer and Phase-Locked Loops (PLL). It concludes with a study of Digital-to-Analog and Analog-to-Digital conversion techniques essential for interfacing analog signals with digital systems.

Course Pre/Co-requisites

A9405 – Electronic Circuit Analysis

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9415.1. Analyze the structure and characteristics of integrated circuits and operational amplifiers.

A9415.2. Design linear and non-linear applications using operational amplifiers.

A9415.3. Construct active filters and regulator circuits using integrated circuits.

A9415.4. Examine the operation and applications of timers and phase-locked loops.

A9415.5. Compare digital-to-analog and analog-to-digital converter architectures in signal processing systems.

Course Syllabus

Unit-I:

Integrated Circuits and Operational Amplifier: Introduction, classification of ICs, chip size and circuit complexity, basic information of Op-Amp and its features, ideal Op-Amp, Op-Amp internal circuit, Op-Amp characteristics - DC and AC.

Unit-II:

Linear Applications of Op-Amp: Inverting and non-inverting amplifiers, adders, subtractors, instrumentation amplifier, integrator and differentiator. **Non-Linear Applications of Op-Amp:** Sample and hold circuit, comparator, multivibrators, oscillators.

Unit-III:

Active Filters: Introduction, Butterworth filters – 1st order, 2nd order low pass and high pass filters, band pass, band reject and all pass filters. **Voltage Regulators:** Introduction, Series Op-Amp regulator, IC Voltage Regulators-IC78XX and IC79XX, IC723 general purpose regulators, Switching Regulator.

Unit-IV:

Timer and Phase Locked Loops: Introduction to IC 555 timer, description of functional diagram, Monostable and Astable operations and applications, Schmitt trigger, PLL (Qualitative analysis only) - introduction, basic principle, phase detector/comparator, Voltage Controlled Oscillator (IC 566), low pass filter, monolithic PLL and applications of PLL

Unit-V:

Data Converters: Introduction, D to C converters - weighted resistor DAC, R-2R ladder DAC, inverted R-2R DAC, A to D converters - parallel comparator type ADC, counter type ADC, successive approximation ADC and dual slope ADC.

Books and Materials

Text Books:

1. Choudhury, D. Roy, and Shail Bala Jain. *Linear Integrated Circuits.* 6th ed., multicolour ed., New Age International Pvt. Ltd., 2021.
2. Sedra, Adel S., and Kenneth C. Smith. *Microelectronic Circuits.* 6th ed., Oxford University Press, 2010.

Reference Books:

1. Gayakwad, Ramakant A., and Rekha S. *Op-Amps and Linear Integrated Circuits.* 4th rev. ed., Pearson Education, 2021.
2. Franco, Sergio. *Design with Operational Amplifiers and Analog Integrated Circuits.* 4th ed., McGraw Hill, 2016.
3. Gray, Paul R., Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer. *Analysis and Design of Analog Integrated Circuits.* 5th ed., Wiley International, 2009.

A9416 – RISC Architectures and ARM Microcontrollers

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	0	0	45	90	3	40	60	100

Course Description

Course Overview

This course provides an introduction to Reduced Instruction Set Computer (RISC) architectures, emphasizing the ARM family of microcontrollers widely adopted in embedded systems, smartphones, and IoT-based applications. It covers fundamental principles of RISC design, ARM Cortex-M architecture, instruction sets, and peripheral interfacing. Students will explore ARM assembly and embedded C programming to develop efficient embedded solutions. Theoretical knowledge will be reinforced through illustrative examples and programming exercises to help learners relate architectural concepts to practical embedded applications.

Course Pre/Co-requisites

A9401 – Digital Logic Design

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9416.1. Describe the architectural features of Intel 8051 and ARM processors in the context of embedded applications.

A9416.2. Illustrate the functional units of ARM architecture including core dataflow, register organization, pipeline structure, and interrupt handling.

A9416.3. Explain the ARM and Thumb instruction sets, addressing modes, and register usage to support embedded system programming.

A9416.4. Develop proficiency in writing embedded programs using ARM C and assembly language constructs such as loops, functions, and pointers.

A9416.5. Design embedded system solutions using Cortex-M processor architecture and its programmer's model for real-time applications.

Course Syllabus

Unit-I:

8051 Architecture: Introduction to family of Intel MCS hardware, Architecture & Programming Model of 8051, Data, Code Memories & Interfacing of External Memory, Importance of SFRs in Timer/Counter, Serial Port & Interrupt Programming.

Unit-II:

ARM Architecture: The RISC design philosophy, The ARM Design Philosophy, Embedded System Hardware, ARM core dataflow model, Registers, Program Status Register, Instruction Pipeline, Interrupts and Vector Table, Architecture Revision, ARM Processor Families.

Unit-III:

ARM & Thumb Instruction Sets: Data Processing Instructions, Addressing Modes, Branch, Load, Store Instructions, PSR Instructions, Conditional Instructions; Register Usage, Other Branch Instructions, Data Processing Instructions, Single - Register and Multi Register Load - Store Instructions, Stack, Software Interrupt Instructions.

Unit-IV:

ARM Programming: Basic C Data Types, Looping Structures, Register Allocation, Function Calls, Pointer Aliasing, Portability Issues. Pointers, Assembly Code using Instruction Scheduling, Register Allocation, Conditional Execution and Loops.

Unit-V:

Advanced ARM Processors: Cortex-M Processor Families: Cortex-M Flavors, Benchmarking, Cortex-M Microarchitecture, Architectural Configuration, Arm Cortex-M Programmer's Model: Instruction Set Architecture, Register Set.

Books and Materials

Text Books:

1. Mazidi, Muhammad Ali, Janice Gillispie Mazidi, and Rolin D. McKinlay. *The 8051 Microcontroller and Embedded Systems.* Prentice Hall of India, 2000.
2. Sloss, Andrew N., Dominic Symes, and Chris Wright. *ARM System Developer's Guide.* Elsevier, 2012
3. Beuchat, René, Florian Deprez, Andrea Guerrieri, and Sahand Kashani. *Fundamentals of System-on-Chip Design on Arm Cortex-M Microcontrollers.* Arm Education Media, 2021.

Reference Books:

1. Ayala, Kenneth J. *The 8051 Microcontroller.* 3rd ed., Cengage Learning, 2008.
2. Deshmukh, Ajay V. *Microcontrollers: Theory and Applications.* Tata McGraw-Hill, 2004.
3. Kamal, Raj. *Embedded Systems: Architecture, Programming and Design.* 3rd ed., McGraw Hill Education India, 2017.

A9417 – Electromagnetic Theory and Transmission Lines

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
45	15	0	60	120	3	40	60	100

Course Description

Course Overview

This course covers static and dynamic electric and magnetic fields and their interaction, electromagnetic induction, Maxwell's equations, solve these equations for various boundary conditions, qualitative treatment of uniform plane waves and guided waves thus enables a student in understanding static and time varying EM fields and EM waves and transmission lines which are of essential importance in modern communications.

Course Pre/Co-requisites

A9002- Ordinary Differential Equations and Vector Calculus A9003- Numerical Methods and Complex Variables

Relevant Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being
SDG 4: Quality Education
SDG 9: Industry, Innovation, and Infrastructure

Course Outcomes

After the completion of the course, the student will be able to:

A9417.1. Interpret electric and magnetic field distributions using vector algebra and vector calculus.

A9417.2. Apply the basic laws of Electromagnetics to determine field intensities.

A9417.3. Apply Maxwell's equations to determine boundary conditions across various media.

A9417.4. Analyze EM waves characteristics in different media.

A9417.5. Analyze the characteristics of the lossy, lossless and distortion less Transmission lines for different load conditions.

Course Syllabus

Unit-I:

Electrostatics: Introduction to Co-ordinate Systems, Coulomb's law, Electric field intensity, Field due to different charge distributions, Electric flux and Flux density, Gauss law and its applications, Electric potential. Maxwell's equations for electrostatic fields, and illustrative problems.

Unit-II:

Magneto Statics: Biot-Savarts law, Amperes circuital law and applications, Magnetic flux and magnetic flux density, Maxwell's equations for magneto static fields. **Boundary Conditions:** Conditions at a boundary surface: dielectric-dielectric and dielectric – conductor interfaces, illustrative problems.

Unit-III:

Time Varying Fields and Maxwells Equations: Faradays law, Inconsistency of Amperes law and displacement current density, Maxwell's equations in differential, integral and word statements.

Unit-IV:

EM Wave Characteristics: Wave motion in free space, perfect, Lossy dielectrics and good conductors, Poynting theorem, Polarization.

Unit-V:

Transmission Lines: Equivalent model, parameters, equations, Infinite line concepts, distortion and its condition, Input impedance of open and short-circuited transmission lines, reflection coefficient and VSWR, Elementary treatment of Smith chart.

Books and Materials

Text Books:

1. Sadiku, Matthew N. O. *Elements of Electromagnetics.* 7th ed., Oxford University Press, 2018.

Reference Books:

1. Hayt, William H., Jr., and John A. Buck. *Engineering Electromagnetics.* 9th ed., Tata McGraw Hill, 2020.
2. Jordan, E. C., and K. G. Balmain. *Electromagnetic Waves and Radiating Systems.* 2nd ed., Prentice Hall of India, 2000.
3. Kraus, John D. *Electromagnetics.* 6th ed., McGraw Hill, 2007.
4. Sinha, Umesh. *Transmission Lines and Networks: Filters and Transmission Lines.* Satya Prakashan, 2012.

A9418 - Digital Signal Processing Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course will give the knowledge in practical abilities of Digital Signal Processing using MATLAB and DSP processors for numerical computations and visualization. This course introduces fundamental concepts, algorithms and applications of digital signal processing. This course investigates the processing and analysis of signals using the most common approaches and algorithms. It provides the necessary background to design and analyze the discrete time system.

Course Pre/Co-requisites

A9406 – Signals and Systems A9409 – System Modelling and Simulation Laboratory Calculus.

Relevant Sustainable Development Goals (SDGs)

SDG 3: Good Health and Well-being
SDG 7: Affordable and Clean Energy
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9418.1. Interpret the concepts of Discrete time signals and systems using MATLAB.

A9418.2. Analyze Discrete time signals and systems using transform techniques using MATLAB.

A9418.3. Implement digital FIR and IIR filters for the given specifications using MATLAB.

A9418.4. Demonstrate the concepts of discrete time signals and systems using DSP processors.

A9418.5. Design digital filters for the given specifications using DSP processors.

Course Syllabus

List of Experiments (Any 12):

The programs shall be implemented using MATLAB/ LAB view/ C Programming/ OCTAVE or Equivalent/ Using TI/Analog Devices/Motorola/ Equivalent DSP processors.

1. Generation of discrete time signals and sequences.
2. Verification of Symmetry and energy/power of a discrete time signal.
3. Verification of linearity and time invariance properties of a given discrete time system.
4. Verification of stability of an LTI system given in (a) difference equation / transfer function and (b) impulse response.
5. Find the response of an LTI system described by the impulse response h(n).
6. Find the impulse and step response of an LTI system described by the difference equation.
7. Find the frequency response of a given system given DT system and plot magnitude and phase response.
8. Find DFT/IDFT of given discrete time signal.
9. Find Linear and Circular Convolution using DFT/IDFT.

10. Implementation of FFT of given sequence.
11. Determination of Power Spectrum of a given Signal(s).
12. Design of Butterworth IIR filters for a given sequence and verify the frequency response of the filter.
13. Design of Chebyshev IIR filters for a given sequence and verify the frequency response of the filter.
14. Design of FIR filter using windowing technique and verify the frequency response of the filter.
15. Generation of DTMF Signals.
16. Implementation of Decimation Process.
17. Implementation of Interpolation Process.
18. Implementation of I/D Sampling Rate Converters.

Laboratory Equipment/Software/Tools Required:

1. PCs installed with operating system
2. MATLAB Software
3. Code Composer Studio
4. TI/Analog Devices/Motorola/ Equivalent DSP processors

Books and Materials

Text Books:

1. Proakis, John G., and Dimitris G. Manolakis. *Digital Signal Processing: Principles, Algorithms, and Applications.* 4th ed., Pearson Education/PHI, 2007.
2. Singh, Avtar, and S. Srinivasan. *Digital Signal Processing.* Thomson Publications, 2006.

Reference Books:

1. Hayes, Monson H. *Schaum's Outline of Digital Signal Processing.* Tata McGraw-Hill, 2007.
2. Schilling, Robert J., and Sandra L. Harris. *Fundamentals of Digital Signal Processing Using MATLAB.* Thomson Publications, 2007.
3. Manolakis, Dimitris G., and Vinay K. Ingle. *Applied Digital Signal Processing.* Cambridge University Press, 2011.

A9419 – Integrated Circuits and Applications Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This laboratory course provides hands-on experience in the design, implementation, and analysis of analog electronic circuits using operational amplifiers and specialized ICs such as IC 741, IC 555, IC 723, and IC 565. The course enables students to explore the functionality and application of op-amps in both linear and non-linear domains. Through systematic experimentation, students gain proficiency in active filters, oscillators, timers, voltage regulators, and analog-to-digital/digital-to-analog converters. Emphasis is laid on analyzing signal behavior, understanding frequency response, interpreting waveform characteristics, and applying theoretical principles to real-world analog system design. This lab serves as a foundation for advanced analog circuit design and embedded system applications.

Course Pre/Co-requisites

A9403 – Electronics Devices and Circuits Calculus.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

Course Outcomes

After the completion of the course, the student will be able to:

A9419.1. Design linear and non-linear circuits using operational amplifiers to realize various signal processing applications.

A9419.2. Analyze the operation of active filters and oscillators with operational amplifiers and evaluate their frequency response.

A9419.3. Demonstrate the timing and control functions of IC 555 through timer-based applications.

A9419.4. Evaluate the performance of voltage regulators and phase-locked loop systems for stability and control in electronic circuits.

A9419.5. Analyze digital-to-analog and analog-to-digital converter circuits for effective signal conversion in electronic systems.

Course Syllabus

List of Experiments:

1. Design and implement an inverting and non-Inverting amplifier using IC741 Op-Amp and calculate gain.
2. Design and implement of Analog Adder and Subtractor Circuits using IC 741 and also verify its functionality.
3. Design a Comparator using IC741 Op-Amp and draw the comparison results of A=B, A<B, A>B.
4. Design and analyze practical Integrator using IC741 Op-amp for different input signals and draw its frequency response.
5. Design and analyze practical Differentiator using IC 741 Op-amp for different input signals and draw its frequency response.

6. Design and analyze 1st and 2nd order Low pass Butterworth filters using IC741 Op-Amp and plot the frequency response.
7. Design and analyze 1st and 2nd order High pass Butterworth filters using IC741 Op-Amp and plot the frequency response.
8. Design a wave generator (sine / square / triangular wave) for the specified frequency using IC741 Op-Amp and draw the output waveform.
9. Analyze three terminal positive and negative fixed voltage regulators (IC78XX, IC79XX) and variable voltage regulator using IC723.
10. Design and analyze Astable and Monostable mode of operation using IC555 timer, draw its output waveform and calculate its duty cycle.
11. Design and analyze a Schmitt trigger circuit using IC555 timer and determine its upper and lower threshold points (UTP & LTP).
12. Analyze the Lock-in range and Capture range of Phase locked loop using IC565.
13. Design R-2R ladder DAC and find its resolution and write a truth table with respective voltages.
14. Design and analyze Parallel comparator type Analog to Digital converter using Op-amps and 8 to 3 priority encoders.

Laboratory Equipment/Software/Tools Required:

1. Cathode Ray Oscilloscope
2. Function Generator
3. Regulated Power Supply
4. Multimeters
5. Discrete Components
6. Breadboard
7. Computers installed with operating system
8. Multisim Software

Books and Materials

Text Books:

1. Choudhury, D. Roy, and Shail Bala Jain. *Linear Integrated Circuits.* 6th ed., multicolour ed., New Age International Pvt. Ltd., 2021.
2. Sedra, Adel S., and Kenneth C. Smith. *Microelectronic Circuits.* 6th ed., Oxford University Press, 2010.

Reference Books:

1. Gayakwad, Ramakant A., and Rekha S. *Op-Amps and Linear Integrated Circuits.* 4th rev. ed., Pearson Education, 2021.
2. Franco, Sergio. *Design with Operational Amplifiers and Analog Integrated Circuits.* 4th ed., McGraw Hill, 2016.
3. Gray, Paul R., Paul J. Hurst, Stephen H. Lewis, and Robert G. Meyer. *Analysis and Design of Analog Integrated Circuits.* 5th ed., Wiley International, 2009.

A9420 – RISC Architectures and ARM Microcontrollers Laboratory

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course offers hands-on experience in embedded systems programming using ARM-based microcontrollers LPC2148/2929 (ARM7/9) and STM32 (Cortex-M). Students will explore assembly and Embedded C programming, memory operations, peripheral interfacing, and register-level access using Keil and Cube IDEs. Advanced modules cover real-time audio data acquisition and classification using NanoEdge AI Studio, enabling intelligent edge computing. The course bridges theoretical knowledge and practical skills essential for designing modern embedded and AI-integrated IoT applications.

Course Pre/Co-requisites

A9401 - Digital Logic Design A9415 – RISC Architectures and ARM Microcontrollers.

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 8: Decent Work and Economic Growth
SDG 9: Industry, Innovation, and Infrastructure
SDG 11: Sustainable Cities and Communities
SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9420.1. Compile embedded programs in ARM assembly and C for LPC2148/2929 to perform computation and control tasks.

A9420.2. Make use of Keil and Cube IDE tools for developing, debugging, and deploying ARM-based embedded applications.

A9420.3. Interface peripheral devices like LEDs, LCDs, buzzers, ADCs, and switches with LPC2148/2929 and STM32.

A9420.4. Integrate GPIOs and sensors on STM32 to implement edge-level signal acquisition and interaction.

A9420.5. Build real-time audio classification systems using STM32 and NanoEdge AI Studio for smart applications.

Course Syllabus

Cycle-I: LPC2148/2929 (ARM7TDMI-S / NXP LPC2929) Programming in both ALP & Embedded C using Keil Compiler)

1. Implement advanced memory access and control transfer operations using LDMFD, STMFD, B, and BL instructions.
2. Perform basic register and memory access with arithmetic and logical operations.
3. Modify processor state using MRS/MSR instructions and define the start address of the text segment via command-line configuration.
4. Program and verify LED blinking and seven-segment display control on LPC2148/2929 microcontrollers.

5. Interface and control an alphanumeric LCD module using LPC2148/2929 for data display.
6. Interface a 16-channel ADC with LPC2148/2929 and acquire analog input signals.
7. Display numeric values on a seven-segment display through embedded programming.
8. Interface a buzzer with the LPC2148/2929 microcontroller and control its operation through embedded code.

Cycle-II: STM32(ARM Cortex) using Nano Edge AI studio and Cube IDE

1. Demonstrate on-board LED and Switch operation.
2. Configure user button press using GPIO interrupts
3. Interface audio sensor to STM32 Nucleo board.
4. Implement a data logger to send data from STM32 to Nano Edge AI studio.
5. Running Data Logger code to classify audio on NanoEdge AI Studio
6. Design of a ML based audio classification to identify & classify different sounds

Laboratory Equipment/Software/Tools Required:

1. Personal Computer
2. Keil C compiler
3. NanoEdge AI Studio
4. LPC2148 boards
5. STM32 boards
6. LEDs and Switches
7. LCD modules
8. ADC modules
9. Buzzers

Books and Materials

Text Books:

1. Mazidi, Muhammad Ali, Janice Gillispie Mazidi, and Rolin D. McKinlay. *The 8051 Microcontroller and Embedded Systems.* Prentice Hall of India, 2000.
2. Sloss, Andrew N., Dominic Symes, and Chris Wright. *ARM System Developer's Guide.* Elsevier, 2012
3. Beuchat, René, Florian Deprez, Andrea Guerrieri, and Sahand Kashani. *Fundamentals of System-on-Chip Design on Arm Cortex-M Microcontrollers.* Arm Education Media, 2021.

Reference Books:

1. Ayala, Kenneth J. *The 8051 Microcontroller.* 3rd ed., Cengage Learning, 2008.
2. Deshmukh, Ajay V. *Microcontrollers: Theory and Applications.* Tata McGraw-Hill, 2004.
3. Kamal, Raj. *Embedded Systems: Architecture, Programming and Design.* 3rd ed., McGraw Hill Education India, 2017.

A9421 – FPGA-Based System Design

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	30	0	30	1	40	60	100

Course Description

Course Overview

This course provides hands-on experience in designing digital systems using Verilog HDL and implementing them on FPGA platforms like the Boolean Board, Spartan 3E and PYNQ-Z2. Students learn to model combinational and sequential circuits using various HDL styles and work with tools like AMD Vivado. The course also introduces hardware-software co-design through the PYNQ framework, enabling real-time applications in image processing and machine learning using Python and Jupyter notebooks.

Course Pre/Co-requisites

A9401 - Digital Logic Design

A9410 - Applied Python Programming Laboratory

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education

SDG 9: Industry, Innovation, and Infrastructure

SDG 11: Sustainable Cities and Communities

SDG 12: Responsible Consumption and Production

Course Outcomes

After the completion of the course, the student will be able to:

A9421.1. Apply Boolean algebra and minimization techniques to simplify a Boolean function.

A9421.2. Build combinational and sequential circuits using various modeling styles of Verilog HDL.

A9421.3. Design a digital system using Finite State Machines and Programmable Logic Devices.

A9421.4. Apply PYNQ-Z2 board and Python APIs to control peripherals and interfaces via overlays and Jupyter Notebooks.

A9421.5. Develop and test simple image processing and machine learning applications on the PYNQ-Z2 using prebuilt overlays.

Course Syllabus

Theory

Verilog HDL: Introduction to HDL - Hierarchical modeling concepts, lexical conventions, data types, modules and ports, different types of modeling (Gate level, data flow, and behavioral), Structural Modeling: Gate primitives in Verilog, Module instantiation. **Data Flow Modeling:** Expressions, operands and operators, continuous assignment statements, **Behavioral Modelling:** Initial and always blocks, procedural statements, conditional, case, and loop statements. **Advanced Verilog concepts:** Compiler directives, combinational and sequential UDPs.

FPGA and Vivado: Introduction to PYNQ Z2, FPGA and SoC Fundamentals, PYNQ Framework, Vivado Design Suite Basics, Overlay Concept in PYNQ, Communication Interfaces, Memory and Data Management, Hardware-Software Co-Design, PYNQ Python Libraries.

Practice

1. Design of Processing Element (MAC Unit) using VIO and ILA
2. Perform Matrix Multiplication using Vitis IDE (Processor-based Implementation)
3. Design and Synthesis of Array Multiplier IP using HLS C Code
4. Integration of HLS IP with Zynq Processor (ZedBoard/PYNQ-Z2) and Control using Processor
5. Design Accelerator for Direct Convolution Operation using HLS C Code
6. Design Accelerator for GEMM-based Convolution Operation and Compare with Direct Convolution
7. Design Accelerator for Activation Functions (ReLU, Sigmoid, Tanh) using HLS
8. Design Accelerator for Pooling Layer (Max/Average Pooling)
9. Design Fixed-Point Accelerator Architecture for CNN Layers
10. Develop Accelerator for a Simple ANN Model (e.g., Iris Dataset)
11. Develop Accelerator for CNN Model (e.g., MNIST Dataset)
12. Execute ML Programs on ARM Processor (PYNQ-Z2)
13. Train and Deploy a Quantized Model on Edge TPU (TF-Lite + Post-Training Quantization)
14. Run Trained Model on Edge TPU and Analyze Performance (FPS, Latency, Accuracy)

Laboratory Equipment/Software/Tools Required:

1. PCs installed with operating system
2. AMD Vivado™ Design Suite
3. Real Digit Boolean Board/Spartan 3E FPGA Boards
4. Pynq Z2 FPGA Kit

Books and Materials

Text Books:

1. Palnitkar, Samir. *Verilog HDL: A Guide to Digital Design and Synthesis.* 2nd ed., Pearson Education, 2013.
2. Crockett, Louise H., Ross A. Elliot, Martin A. Enderwitz, and Robert W. Stewart. *Exploring Zynq MPSoC: With PYNQ and Machine Learning Applications.* Strathclyde Academic Media, 2019.

Reference Books:

1. Mano, M. Morris, and Michael D. Ciletti. *Digital Design: With an Introduction to the Verilog HDL, VHDL, and System Verilog.* 6th ed., Pearson Education, 2018.
2. Wolf, Wayne. *FPGA-Based System Design.* Pearson Education, 2004.

A9024 – Community Driven Product Evaluation

Teaching and Learning Scheme				Hours	Credits	Assessment Marks		
CI		LI	TW+SL	H	C	CIE	SEE	Total
L	T	P	SL					
0	0	0	45	45	1	40	60	100

Course Description

Course Overview

This course provides mathematical knowledge required to analyze problems encountered in engineering. In this course, the students are acquainted with ordinary differential equations of first and higher order and Laplace transforms, vector calculus. In addition, this course can be applied in many areas of engineering such as wireless communication, signal processing, robotics and animation.

Course Pre/Co-requisites

A9023 - Technology Entrepreneurship

Relevant Sustainable Development Goals (SDGs)

SDG 4: Quality Education
SDG 11: Sustainable Cities and Communities
SDG 12: Responsible Consumption and Production
SDG 17: Partnerships for the Goals

Course Outcomes

After the completion of the course, the student will be able to:

A9024.1. Apply structured evaluation frameworks to assess technical, functional, and social impact of products.

A9024.2. Conduct community-centered product testing and collect actionable feedback.

A9024.3. Benchmark products against industry standards and competitor solutions.

A9024.4. Analyze evaluation data to identify strengths, weaknesses, and areas for improvement.

A9024.5. Integrate knowledge from all prior courses to produce a comprehensive commercialization or patent readiness report.

Course Syllabus

Unit-I:

Product Evaluation Fundamentals: Purpose, scope, and importance of product evaluation in community contexts. Key Performance Indicators (KPIs), usability, and sustainability metrics. Ethical considerations in testing with communities.

Unit-II:

Standards, Compliance and Benchmarking: Relevant industry, safety, and environmental standards. Social impact and sustainability assessment frameworks. Competitive benchmarking and market gap analysis.

Unit-III:

Community Centered Testing and Data Collection: Designing and executing real-world product trials. Feedback mechanisms: surveys, interviews, observation, analytics. Collecting and categorizing qualitative and quantitative data.

Unit-IV:

Data Analysis and Product Improvement Planning: Analytical tools for interpreting evaluation results. Identifying design gaps and improvement opportunities. Translating insights into actionable product enhancement plans.

Unit-V:

Integrated Product Documentation: Consolidating insights from design thinking, product development, entrepreneurship, and evaluation. preparing a comprehensive commercialization or patent readiness dossier. and presenting outcomes to a review panel for validation and approval.

Activity Plan

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
1	Unit-I: Evaluation Fundamentals	Understand purpose, scope & importance of product evaluation	Concept briefing	Discussion: "Why evaluation is crucial for community-driven products"	Reflection note on role of evaluation in product lifecycle	CO1
2	Unit-I: KPIs & Metrics	Learn KPIs, usability & sustainability measures	Concept briefing + Case examples	Teams define KPIs for a sample product	Submit KPI framework for selected case	CO1
3	Unit-I: Ethics in Evaluation	Apply ethical considerations in testing	Problem-based learning + Collaborative exchange	Debate: "Ethics vs. Innovation speed in testing"	Short essay on ethical challenge in testing	CO1
4	Unit-II: Standards & Compliance	Learn relevant industry & safety standards	Demo session + Case study	Review product compliance requirements from standards body	Submit compliance checklist for a product	CO2, CO3
5	Unit-II: Benchmarking	Apply benchmarking frameworks	Hands-on session + Benchmarking activity	Benchmark 2 community products against market leaders	Submit benchmarking chart	CO3
6	Unit-II: Market Gap Analysis	Identify market gaps & opportunities	Hands-on session	Teams map competitor strengths vs weaknesses	Submit market gap report	CO3
7	Unit-III: Community-Centered Testing	Design product trials with stakeholders	Hands-on workshop + Role-play	Simulate community feedback session	Submit trial design protocol	CO2

Week	Unit	Objective	Teaching Method	In-Class Activities	Assignments / Assessments	CO Mapping
8	Unit-III: Feedback Mechanisms	Practice data collection methods	Practical session + Peer feedback	Run mock survey/interview for a prototype	Submit collected sample data	CO2
9	Unit-IV: Data Analysis Tools	Analyze evaluation data	Analytical lab + Software demo	Use basic data tools (Excel/SPSS/PowerBI) to interpret results	Submit initial analysis report	CO4
10	Unit-IV: Product Improvement	Translate insights into action	Product improvement exercise	Teams identify weaknesses & propose enhancements	Submit product improvement plan	CO4
11	Unit-V: Integrated Documentation	Consolidate learnings from all prior courses	Documentation	Draft commercialization or patent dossier	Submit draft dossier	CO5
12	Unit-V: Final Showcase	Present integrated evaluation outcomes	Showcase + Expert panel review	Final presentations with reports, feedback loop	Submit final commercialization/patent readiness dossier	CO5

Books and Materials

Text Books:

1. Deependra Sharma *Entrepreneurship in India*, Routledge, 2023.
2. Cooper, Robert G *Winning at New Products: Creating Value Through Innovation*, Basic Books, 2011.

Reference Books:

1. Dr. S. Glory Swarupa, Swapna Vanamala *Innovation, Incubation and Intellectual Property Rights: Experiences of Developing Countries*, 2023.